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**ENDURANCE PUMP TESTS WITH  
FRESH AND PURIFIED MIL-PRF-  
83282 HYDRAULIC FLUID**



**Materials & Manufacturing Directorate  
Air Force Research Laboratory  
Air Force Materiel Command  
Wright-Patterson AFB OH 45433-7734**

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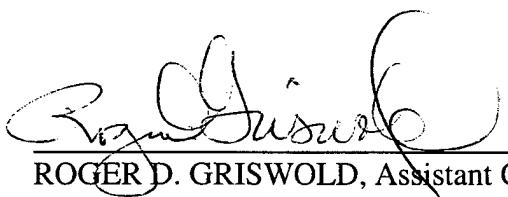
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Recently the US Armed Forces began using portable external purifiers to clean used hydraulic fluid to permit its continued use in aircraft systems and to reduce the hydraulic fluid waste stream. Two endurance pump tests were conducted with F-16 aircraft hydraulic pumps, using both fresh and purified MIL-PRF-83282 hydraulic fluid, to determine if fluid purification had any adverse effect on pump life. The first test was conducted using fresh MIL-PRF-83282 hydraulic fluid. The second test was conducted with hydraulic fluid that was circulated for 75 minutes through a fluid purifier after every 300 hours of pump testing. The failure modes were similar for both the tests. In the first test, the barrel-bearing failed after 1343 hours whereas, in the second test, both the shaft-bearing and the barrel-bearing failed after 1513 hours. The difference in the bearing lives from the two tests is not significant. Rolling element bearings, made out of AISI 52100 steel, seem to be the weak link in the F-16 main hydraulic pump. The pump life may be considerably increased by the use of better bearing material such as M50 steel. There was no significant difference in pump performance. The fluid purification did not adversely affect the pump life.				
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Endurance Pump Tests  
With  
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## 1.0 INTRODUCTION

Used aircraft hydraulic fluid is one of the largest contributors to the waste stream generated at most US Air Force bases. It is a similar problem for the US Navy bases, for both land and carrier based aircraft. In most cases, the used hydraulic fluid collected is the by-product of an aircraft maintenance action in which some component is being replaced, repaired, etc. The fluid is not being changed because it is "worn out" or extremely contaminated. However, this used fluid is collected in rather large quantities for disposal. It is estimated the Air Force alone uses approximately 1,000,000 gallons of hydraulic fluid per year, much of that in replacing hydraulic fluid lost during maintenance actions. Another source of used hydraulic fluid is ground service equipment that is routinely hooked up to aircraft when the aircraft are serviced. The main purpose of this servicing is to replenish hydraulic fluid which may have been lost due to leakage as well as to provide hydraulic power to check hydraulic system/component performance. The hydraulic fluid coming out of the aircraft is significantly more contaminated than new fluid going in, which is to be expected. The level of contamination is generally not too high for acceptable performance of the aircraft hydraulic system, but is too contaminated to be re-introduced into the aircraft in many cases, which generates more waste stream for disposal.

The armed services have investigated possible avenues to reduce or eliminate this waste stream. The two primary approaches have been reclamation [1] and purification. The reclamation approach has some inherent problems including collection and the need to conduct conformance checks on the quality of the hydraulic fluid before it can be repackaged and sold as used/new fluid. The cost of these conformance checks, which must be performed on every batch of reclaimed fluid, coupled with the relatively low cost of new fluid, has essentially eliminated this approach on the basis of economics. The purification approach, however, appears to be quite cost effective due to the ease of the process, the fact the fluid never leaves the site at which the used fluid is generated and the fewer tests which need to be conducted to assure adequate performance.

All three US armed services have, to some extent, utilized fluid purification as a means to minimize their hydraulic fluid waste stream. One of the problems with the utilization has been the lack of documentation of testing done to assure the used fluid has been adequately purified and the purified fluid is acceptable for use in these very expensive weapons systems. One exception is the work done by the U.S. Army [2]. In field tests of ground vehicles, the Army found that the mixture of purified used-fluid and fresh MIL-H-46170 performed acceptably. The main factors investigated by most potential users in assessing whether or not hydraulic fluid purifiers could be used to reduce the hydraulic fluid waste stream were the contamination levels (i.e., particulate, water and halogenated solvent) in the hydraulic fluid after it had been purified. That does not address the possible deterioration of the fluid during use or the potential for the purifier to remove some of the performance improving additives from the fluid as well as the contaminants.

If the mean time between failure of a hydraulic system component were reduced by as little as 10-20%, the economics of using fluid purification to reduce the cost of operation by minimizing the waste stream would probably not be very attractive. Additionally, it would be difficult to detect such a small, but significant change in component life until the purified fluid had been applied across the fleet and an extensive drain, purge and fill program would be required to remedy the problem.

A long-term hydraulic component test under carefully controlled conditions would be advisable to assess the potential negative effect a fluid purifier could have on hydraulic fluid performance. Since the hydraulic pump in a system is generally considered to be the component most sensitive to most of the properties of a hydraulic fluid (e.g., viscosity, lubricity, foaming, etc.), it was selected to be the test article. Some Air Force aircraft use MIL-H-5606 and MIL-PRF-87257 while most of them use MIL-PRF-83282. Pump tests with MIL-H-5606 and MIL-PRF-83282 fluids were conducted at the Materials Directorate of the Air Force Research Laboratory, to assess any negative impact of the fluid purification.

The results of the pump tests with MIL-H-5606 were previously reported [3] and are summarized here. Pump tests with both fresh and purified MIL-H-5606 fluids were successfully completed, and there was no apparent difference in pump performance with either fluid. There was significant viscosity loss in both the fresh and the purified fluid tests. This is a characteristic of the fluids containing viscosity-index-improving additives. The reduction in viscosity with test time caused a corresponding increase in case drain flow. There was no significant change in the other fluid properties monitored. In the test with fresh MIL-H-5606, the main shaft that acts as the inner race for the needle bearing, showed considerable spalling. Polishing wear was observed on most of the pump parts and there was some erosion on the cylinder block face and on piston shoe faces. The erosion on the piston shoe faces was somewhat more with the purified fluid than observed in the test with fresh MIL-H-5606. No degradation in the pump performance was observed due to shaft spalling or the erosion on cylinder block and piston shoe faces. Some pump manufacturers thought the increased erosion on the bronze piston-shoes in the purified MIL-H-5606 test could be due to the removal of dissolved air from the fluid, during purification. Pump tests with de-aerated hydraulic fluid are planned to address this issue.

The in-house pump testing of fresh and purified MIL-PRF-83282 hydraulic fluid is the subject of this report.

NOTE: The use of the Pall Purifier in this program does not constitute endorsement of the unit. It was selected for these tests for two reasons: 1) this unit was already owned by the Air Force and was provided by Eglin Air Force Base; and 2) identical units are the ones most widely used in the field. Testing other brands and models of purifiers was beyond the scope of this program.

## **2.0 TEST OBJECTIVE**

The objective of this program was to perform endurance pump testing using both fresh and purified MIL-PRF-83282 hydraulic fluid, to determine if fluid purification had any adverse effect on pump life.

## **3.0 APPROACH**

The approach proposed and approved was to run long term tests with both fresh and purified MIL-PRF-83282 hydraulic fluid in the AFRL/MLBT in-house pump test facility. Fluid samples were taken at selected intervals during both tests and key physical and chemical properties were determined. The pump operating characteristics were monitored and the pump was disassembled for visual inspection periodically during both tests.

The 2000-hour tests were planned on two F-16 main hydraulic pumps (Abex Model AP12V-17), to determine if purifying the hydraulic fluid was acceptable from the standpoint of fluid properties and pump wear. The test pump is a constant pressure, variable displacement pump rated at 42.5 gpm, 3100 psig, and 5800 rpm. If the purifier removed any of the additives from the fluid, it could make the fluid unacceptable for reuse. Also, if the fluid properties were changed significantly, it could affect pump performance and/or wear.

A baseline test was conducted using MIL-PRF-83282 hydraulic fluid without circulating the fluid through the purifier. The second test was conducted with hydraulic fluid that was circulated for 75 minutes through the Pall purifier after every 300 hours (approx.) during the test. A comparison of the pump test results was carried out to see if fluid purification had any adverse effect on pump life.

After 1000 test hours in each test, ~ 300 ppm water was added to the test fluid. This was done to see if the water-additive interaction had any negative impact.

Each pump was initially disassembled to photograph the parts and then again at 1000 hours to check pump wear and photograph the parts. At the conclusion of each test, the pump was disassembled once more and photographed.

### 3.1 PUMP TEST PLAN

**TEST 37:** Baseline

**Stage I:** Fresh MIL-PRF-83282

**Stage II:** Fluid from Stage I with 300 ppm water (total)

**TEST 38:** Purified Fluid

**Stage I:** Purified Fresh MIL-PRF-83282

**Stage II:** Fluid from Stage I with 300 ppm water (total)

**TEST PUMP:** Abex Model AP12V-17 pressure compensated, variable delivery pump. A new (or rebuilt) pump shall be used for each test. A picture of the test pump is shown in Figure 1.

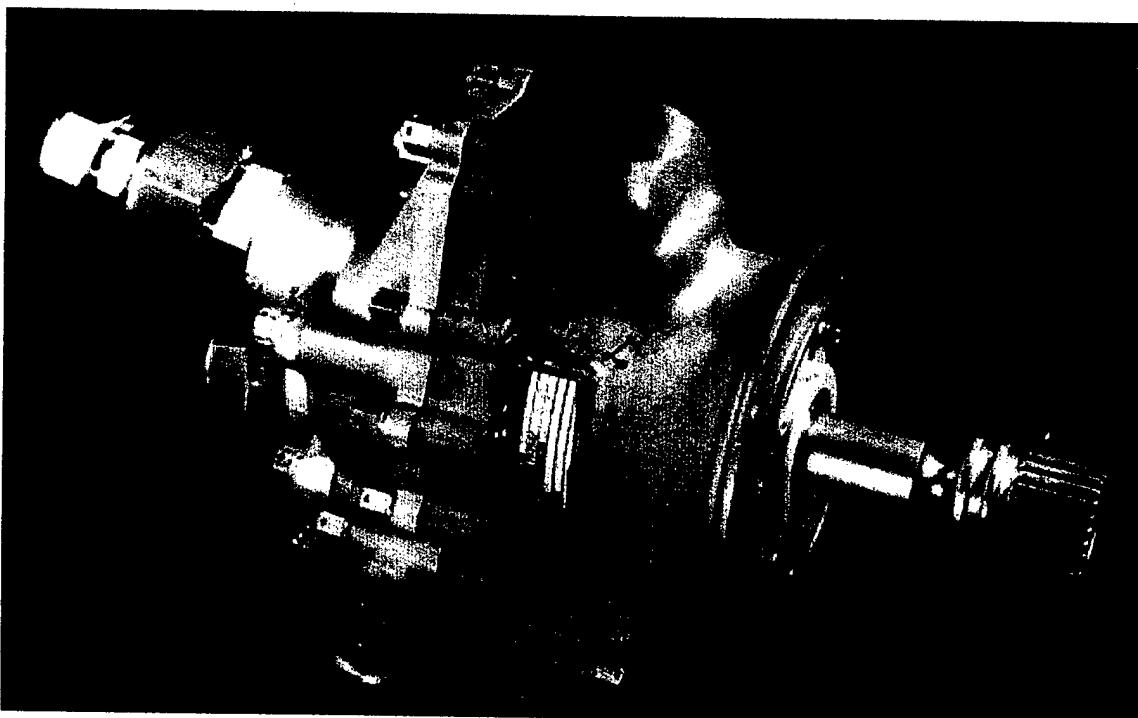


Figure 1. Abex Hydraulic Pump, Model AP12V-17

#### PUMP SPECIFICATIONS:

Rated Pressure:	3100	psi
Rated Flow:	42.5	gpm
Speed:	5800	rpm
Rated Temperature (inlet):	240	°F

**PURIFIER:** Pall Corp. Model PE-00440-1H

**PRE-TEST AND POST TEST INSPECTION:**

1. Partially disassemble the pump to inspect valve plate, cylinder barrel, pistons, yoke and other critical surfaces. **DO NOT DISASSEMBLE** the piston-shoe assembly. Mark the pistons and the corresponding cylinder bores (with Kimwipe) to make sure the pistons go back in their corresponding original cylinder bores during reassembly.
2. Take necessary photographs to document the general condition of the pump, with minimum disassembly.

**TEST CONDITIONS:**

Pump Shaft Speed:	5000 rpm
Pump Inlet Pressure:	80-90 psig
Pump Outlet Pressure:	3100 psig
Max Fluid Temperature:	250 °F
Pump Outlet Flow:	Cycle between 28 gpm and 36 gpm every minute
Case Drain Pressure:	95-105 psig

NOTE:      Manual Valve      constant flow rate of 22 gpm  
                 Throttling Valve      cycle between 6 gpm and 14 gpm

**TEST DURATION:** 2000 total hours or performance degradation, whichever comes first.

<b>Stage I</b>	1000 Hours or performance degradation, whichever comes first
<b>Stage II</b>	1000 Hours or performance degradation, whichever comes first

**TEST 37:**

**Stage I:**

1. Fill the test stand with fresh MIL-PRF-83282 and bleed (remove the entrained air in the test fluid). Take 100 ml fluid sample right after bleeding the stand.
2. Pressurize the stand to 80-90 psig.
3. With the manual valve closed and the throttling valve at its minimum flow setting (approximate flow rate of 6 gpm), start the test and gradually increase the pump speed to 5000 rpm. The speed increase should be continuous and precautions must be taken not to dwell on any critical speeds.

4. Open the manual valve slowly to its maximum flow rate of 22 gpm, such that the total system output flow is approximately 28 gpm. Maintain case drain pressure between 95-105 psig.
5. Stabilize the fluid temperature so that the maximum temperature anywhere in the circuit is 245-250°F (usually in the case drain).
6. Begin cycling the throttling valve from minimum setting (6 gpm) to its maximum setting (14 gpm). At this point, the total main flow should cycle between 28 gpm and 36 gpm.
7. Maintain case drain pressure between 95-105 psig and inlet pressure between 80-90 psig.
8. Take 100 ml fluid samples at 50, 100, 300, 600 and 1000 hours.
9. Stop the test after 1000 hours for pump tear-down/inspection. Do not drain the fluid from the stand.
10. Tear down the pump and photograph the pump parts (DO NOT DISASSEMBLE THE PISTON ASSEMBLY).

#### **Stage II:**

1. Reassemble the pump and install it back on the test stand.
2. Check the water content in the test fluid.
3. If the water content is less than 250 ppm, inject distilled water in the fluid reservoir. Total water content in the fluid should not exceed 350 ppm (should be as close to 300 ppm as possible).
4. Bleed the test stand and pressurize to 80-90 psig.
5. With the manual valve closed and the throttling valve at its minimum flow setting (approximate flow rate of 6 gpm), start the test and gradually increase the pump speed to 5000 rpm. The speed increase should be continuous and precautions must be taken not to dwell on any critical speeds.
6. Open the manual valve slowly to its maximum flow rate of 22 gpm, such that the total system output flow is approximately 28 gpm. Maintain case drain pressure between 95-105 psig.
7. Stabilize the fluid temperature so that the maximum temperature anywhere in the circuit is 245-250°F (usually in the case drain).
8. Check the water content in the test fluid. If the water content is less than 250 ppm, shut down the stand and depressurize.
9. Repeat steps 3-8 of **Stage II** until the water content in the test fluid is 250-350 ppm.
10. Begin cycling the throttling valve from minimum setting (6 gpm) to its maximum setting (14 gpm). At this point, the total main flow should cycle between 28 gpm and 36 gpm.
11. Maintain case drain pressure between 95-105 psig and inlet pressure between 80-90 psig.
12. Take 100 ml fluid sample at 1250 hours

13. Check water content in the fluid from step 12. If the water content is less than 250 ppm, shut down the stand and depressurize.
14. Repeat steps 3-11 of **Stage II** until the water contents in the test fluid is 250-350 ppm (should be as close to 300 ppm as possible).
15. Begin cycling the throttling valve from minimum setting (6 gpm) to its maximum setting (14 gpm). At this point, the total main flow should cycle between 28 gpm and 36 gpm.
16. Maintain case drain pressure between 95-105 psig and inlet pressure between 80-90 psig.
17. Take fluid sample (150 ml) at 1500 hours.
18. Check water content in the fluid from step 17. If the water content is less than 250 ppm, shut down the stand and depressurize.
19. Repeat steps 3-11 of **Stage II**.
20. Take 100 ml fluid sample at 1750 hours
21. Check water content in the fluid from step 20. If the water content is less than 250 ppm, shut down the stand and depressurize.
22. Repeat steps 3-11 of **Stage II**.
23. Stop the test after 2000 total hours or when degradation of performance is observed. Take a 150 ml fluid sample. Tear down the pump completely and photograph the pump parts. Save filter elements and fluid from the test.

### TEST 38:

#### Stage I:

1. Purify fresh MIL- PRF -83282 for 75 minutes.
2. Fill the test stand with this fluid and bleed. Take 100 ml fluid sample right after bleeding the stand.
3. Pressurize the stand to 80-90 psig.
4. With the manual valve closed and the throttling valve at its minimum flow setting (approximate flow rate of 6 gpm), start the test and gradually increase the pump speed to 5000 rpm. The speed increase should be continuous and precautions must be taken not to dwell on any critical speeds.
5. Open the manual valve slowly to its maximum flow rate of 22 gpm, such that the total system output flow is approximately 28 gpm. Maintain case drain pressure between 95-105 psig.
6. Stabilize the fluid temperature so that the maximum temperature anywhere in the circuit is 245-250°F (usually in the case drain).
7. Begin cycling the throttling valve from minimum setting (6 gpm) to its maximum setting (14 gpm). At this point, the total main flow should cycle between 28 gpm and 36 gpm.
8. Maintain case drain pressure between 95-105 psig and inlet pressure between 80-90 psig.

9. Take 100 ml fluid sample after 50 and 100 hours of running.
10. Take 100 ml fluid sample after 300 hours and stop the test.
11. Drain the stand and run the test fluid through the purifier for 75 minutes. Take a 100 ml sample of the purified fluid.
12. Fill the stand with the test fluid (from 11) and bleed.
13. Repeat steps 3-8.
14. Take 100 ml fluid sample at 600 hours and stop the test.
15. Repeat steps 11-13.
16. Take 100 ml fluid sample at 1000 hours and stop the test for pump tear-down/inspection.
17. Disassemble the pump and photograph the pump parts (DO NOT DISASSEMBLE THE PISTON ASSEMBLY).
18. Drain the stand and run the test fluid through the purifier for 75 minutes. Take a 100 ml sample of the purified fluid.

#### **Stage II:**

1. Reassemble the pump and install it back on the test stand. Fill the stand with the purified fluid from step 18 of **Stage I**.
2. Check the water content in the test fluid.
3. If the water content is less than 250 ppm, inject distilled water in the fluid reservoir.
4. Bleed the test stand and pressurize to 80-90 psig.
5. With the manual valve closed and the throttling valve at its minimum flow setting (approximate flow rate of 6 gpm), start the test and gradually increase the pump speed to 5000 rpm. The speed increase should be continuous and precautions must be taken not to dwell on any critical speeds.
6. Open the manual valve slowly to its maximum flow rate of 22 gpm, such that the total system output flow is approximately 28 gpm. Maintain case drain pressure between 95-105 psig.
7. Stabilize the fluid temperature so that the maximum temperature anywhere in the circuit is 245-250°F (usually in the case drain).
8. Check the water content in the test fluid. If the water content is less than 250 ppm, shut down the stand and depressurize.
9. Repeat steps 3-8 of **Stage II** until the water contents in the test fluid is 250-350 ppm (should be as close to 300 ppm as possible).
10. Begin cycling the throttling valve from minimum setting (6 gpm) to its maximum setting (14 gpm). At this point, the total main flow should cycle between 28 gpm and 36 gpm.
11. Maintain case drain pressure between 95-105 psig and inlet pressure between 80-90 psig.
12. Take 100 ml fluid sample after 1250 test hours and stop the test.
13. Drain the stand and run the test fluid through the purifier for 75 minutes. Take a 100 ml sample of the purified fluid.

14. Fill the stand with the test fluid (from 13).
15. Repeat steps 2-11 of **Stage II**.
16. Take 150 ml fluid sample after 1500 test hours and stop the test.
17. Drain the stand and run the test fluid through the purifier for 75 minutes. Take a 100 ml sample of the purified fluid.
18. Fill the stand with the test fluid (from 17).
19. Repeat steps 2-11 of **Stage II**.
20. Take 100 ml fluid sample after 1750 test hours and stop the test.
21. Drain the stand and run the test fluid through the purifier for 75 minutes. Take a 100 ml sample of the purified fluid.
22. Fill the stand with the test fluid (from 21).
23. Repeat steps 2-11 of **Stage II**.
24. Stop the test after 2000 total hours or when degradation of performance is observed. Take a 150 ml fluid sample. Disassemble the pump completely and photograph the pump parts. Save filter elements and fluid from the test

#### **PERFORMANCE PARAMETERS:**

- Flow Rates: pump case drain and pump outlet
- Pressure: pump outlet
- Temperatures: pump inlet, pump outlet, case drain
- Torque:

**FLUID SAMPLE ANALYSES:** A selected number of fluid samples will be analyzed for:

1. Viscosity
2. Water Content
3. Lubricity (4-Ball Wear Test)
4. Foaming
5. Metal Contents

### 3.2 HYDRAULIC PUMP TEST STAND

The pump test stand in AFRL/MLBT was designed primarily for testing new and experimental hydraulic fluids using small to medium displacement aircraft hydraulic pumps. The test stand has been described in previous publications [3, 4]. In order to accommodate the higher flow rates of the F-16 main pump, the test stand was modified as shown in Figures 2 and 3. The case drain flow was routed through the reservoir to keep the test fluid well mixed. The test stand is equipped with a computerized data acquisition system and is designed to run around the clock.

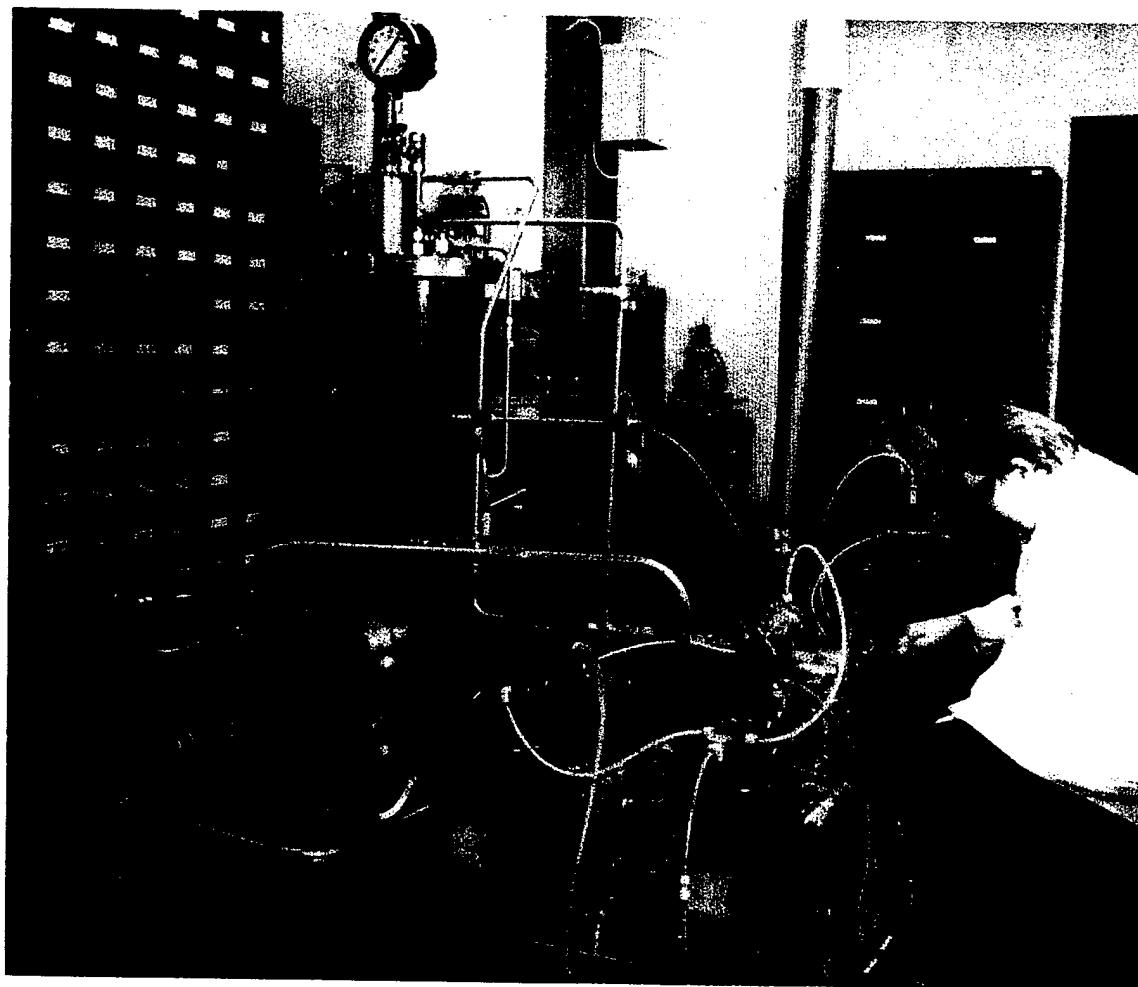


Figure 2. Hydraulic Pump Test Stand

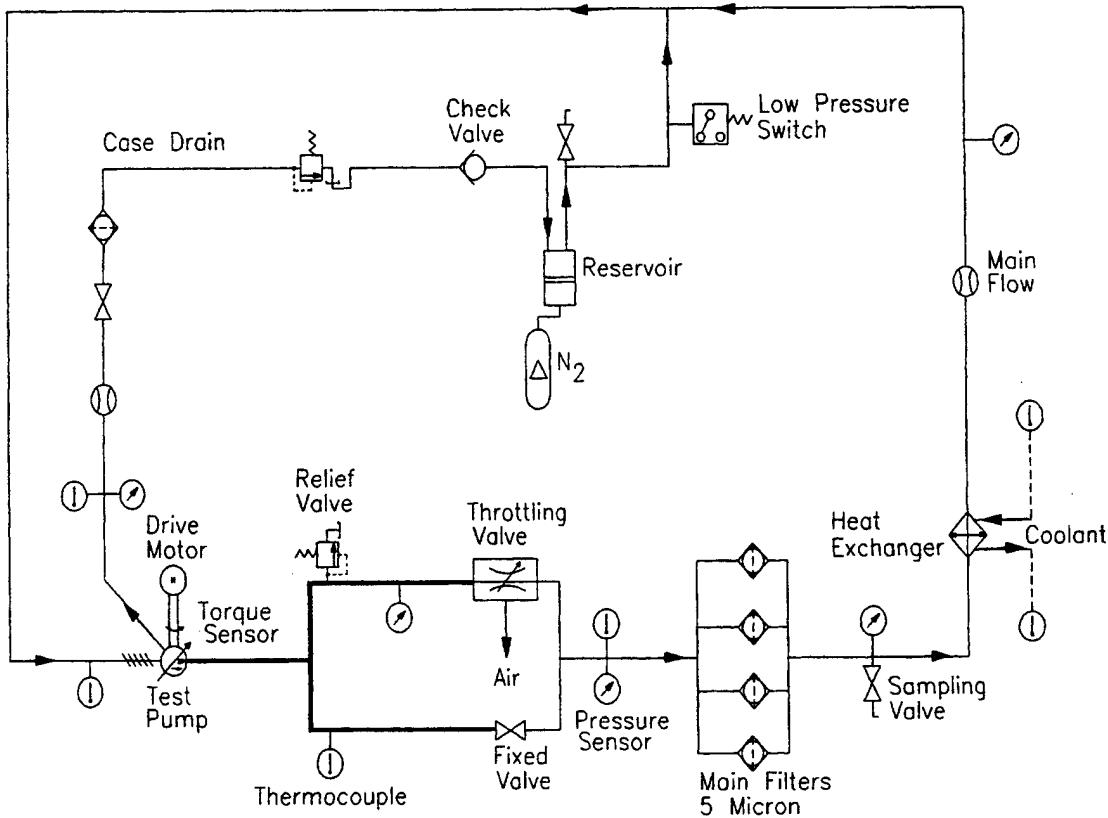


Figure 3. Hydraulic Pump Test Circuit

### 3.3 PORTABLE FLUID PURIFIER

The portable purifier, manufactured by Pall Corporation is designed to remove water, air, chlorinated solvents, and solid contaminants from lubricants and hydraulic fluids. The purifier is a portable system requiring an open space close to the contaminated fluid reservoir and ready access to the required electrical power. A schematic of the purifier is shown in Figure 4.

#### Fluid Purifier Specifications:

Inlet Fluid Temp:	+145 °F (max)/62 °C (max)
Fluid Circulation Rate:	3 gpm (max)
Operating Viscosity:	1300 SSU (max)
Discharge Pressure:	70 psig (max)
Vacuum Chamber Operating VAC:	24 inch Hg $\pm$ 2 inch Hg
Inlet Pressure:	+20 psig (max)
Inlet Pressure:	-10 inch Hg (min)
Power Requirements:	120 Volts, 15 Amps, 60 Hz, and 1 Phase 20 kW max. connected load
Dimensions:	34" H x 27 1/2" W x 34" L (max)

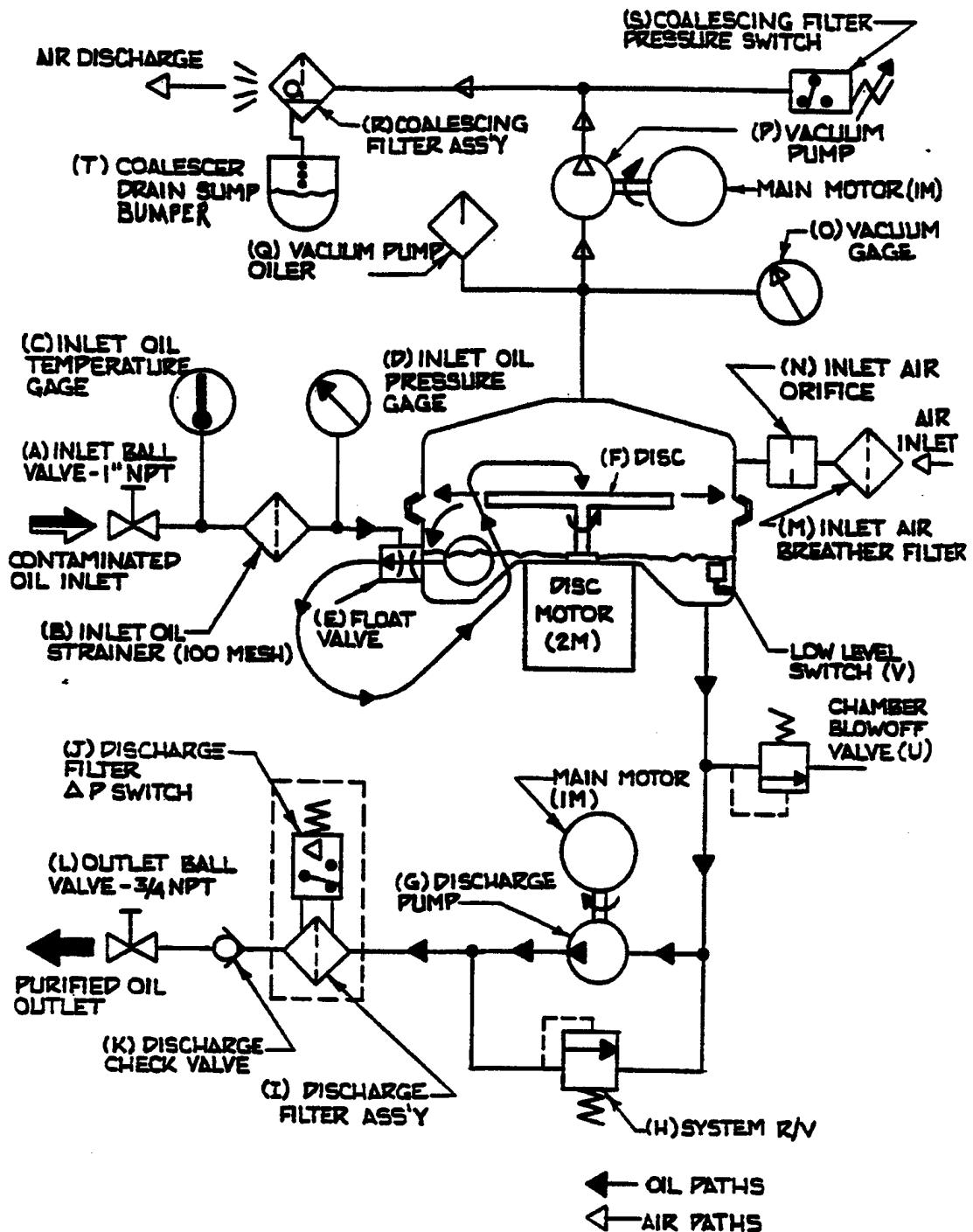


Figure 4. Fluid Purifier Schematic

## 4.0 PUMP TESTS

Pump Test 37 and 38 were conducted according to the test plans in Section 3.1. The pump tests were carried out at the in-house test facility in the Materials and Manufacturing Directorate, Air Force Research Laboratory, Wright-Patterson Air Force Base. The test circuit (see Figure 3) consisted of a drive motor, a throttling valve, a manual/fixed valve, heat exchanger, reservoir, 5 micron filters and other accessories. Various flow, pressure and temperature sensors were used to monitor the test parameters. A torque sensor was mounted between the drive motor and the test pump. The stand was equipped with a computerized data acquisition and control system, with automatic safety interlocks. Data obtained during the tests were also recorded on strip charts. The case drain flow was circulated through the reservoir, to ensure thorough mixing of all the test fluid.

A new or rebuilt pump was used for each test. The pump outlet flow was divided into two paths; a constant flow path through a manual valve and a variable flow path through a cycling throttle valve. Approximately 22 gpm flow was maintained through the manual valve. The flow through the throttling valve was cycled between 6 and 14 gpm every minute. Thus, the total main flow rate varied between 28 gpm and 36 gpm, every minute. Fluid samples were drawn from the sampling port. A total of 15 gallons of fluid was initially placed in the stand, and no new fluid was added during the tests.

A discrepancy was observed in the test-time displayed by the data acquisition system. In the raw data (Appendix-C and Appendix-D), "Test Hours" refers to the time shown by the data acquisition system and the corrected test-time is listed as "Actual Test Hours". Throughout rest of the report, "Test Hours" refers to the corrected test-time.

### 4.1 PUMP TEST WITH FRESH MIL-PRF-83282 (Test 37)

The base-line pump test with the fresh MIL-PRF-83282 fluid was carried out as per the test plan in 3.1. Stage I of the test was completed successfully. At 1000 hours, the test was stopped to inspect the pump. The pictures taken before the test, after 1000 hours and after the completion of the test are shown in Appendix-A. The piston-hanger assembly was not disassembled. The condition of the pump was good and only polishing wear was observed on most of the parts. The pump was re-assembled and installed on the test stand for Stage II testing.

Distilled water was injected into the reservoir in increments until a total 9-ml of water was accumulated in the test fluid. It took approximately 50 hours for the water to thoroughly mix with the test fluid (see Table 1 and Figure 5). At this point the measured water content (219 ppm) matched closely with the calculated value, which clearly showed that an addition of approximately 4.5 ml of water to the test fluid would bring the total water content to ~300 ppm. At 1055.8 hours, 4.5 ml of distilled water was added to the test fluid.

Table 1. Water Calibration – Samples from Test 37 with Fresh MIL-PRF-83282

MLO	TEST HOURS	DATE	INJECTION WATER(ml)	Acid Number mg KOH / g	% RH	Water Content by KF Method			Comments
						Run 1	Run 2	AVG.	
98-52	1001.9	04/20/98			1.0	47	49	48	Approx. 250F
	1003.0	04/20/98	3.0						cold
98-55	1003.6	04/22/98			1.0	56	57	56	Approx. 250F
	1003.8	04/22/98	3.0						cold
98-58	1003.8	04/23/98			8.0	59	64	61	71.70F
98-59	1004.4	04/23/98			1.0	64	67	65	Approx. 250F
	1004.5	04/23/98	3.0						cold
98-60	1004.6	04/27/98			4.0	63	66	65	85.0F
	1009.6	04/29/98			3.0				248.05F
	1041.0	04/30/98			7.0				249.93F
98-70	1052.7	05/01/98			7.5	217	221	219	Approx. 250F
	1055.8	05/01/98	4.5						cold
					8.0	203	207	205	no
	1056.9	05/01/98			8.0				250.68F
	1126.8	05/04/98			7.0				249.18F
98-76	1142.9	05/05/98			6.5	203	207	205	Approx. 250F
	1169.6	05/06/98			6.0				249.80F
	1192.7	05/07/98			5.0				247.18F
98-79	1211.1	05/08/98			5.0	189	194	191	
98-80	1321.4	05/15/98		2.3	4.5	132	139	136	
	1321.7	05/15/98	9.2		4.5				
98-81	1327.5	05/21/98			5.0	152	159	156	250F
98-82	1343.4	05/22/98				240.5	239.8	240	autoshutdown

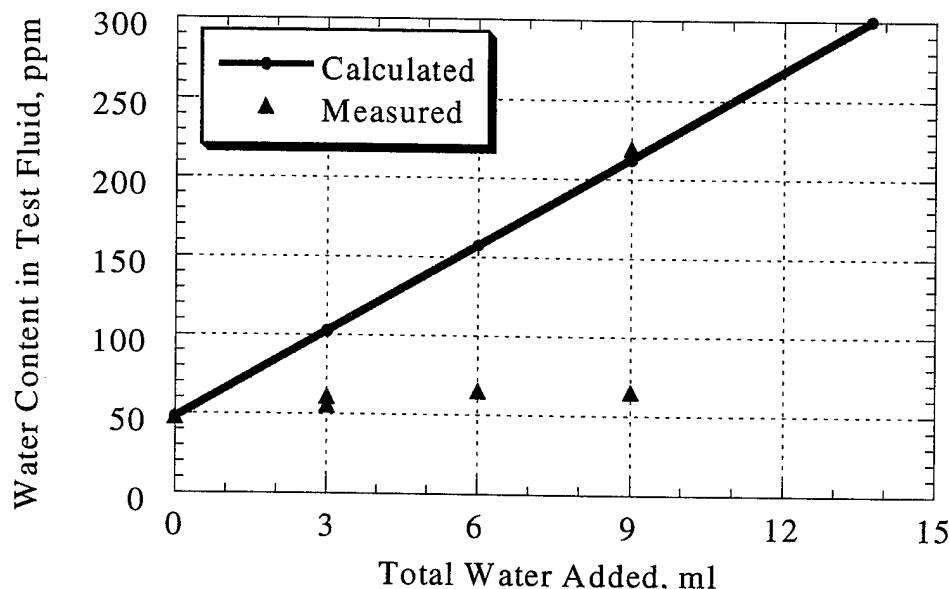


Figure 5. Calibration of Water Content in the Test Fluid for Test 37

The water content in the fluid was continuously monitored with a relative humidity sensor, and it was also measured in the periodic fluid samples. The measured water content was proportional to the % relative humidity measured by the RH (relative humidity)-sensor, as shown in Figure 6. As the test progressed, the water content in the test fluid gradually declined as shown in Figure 7.

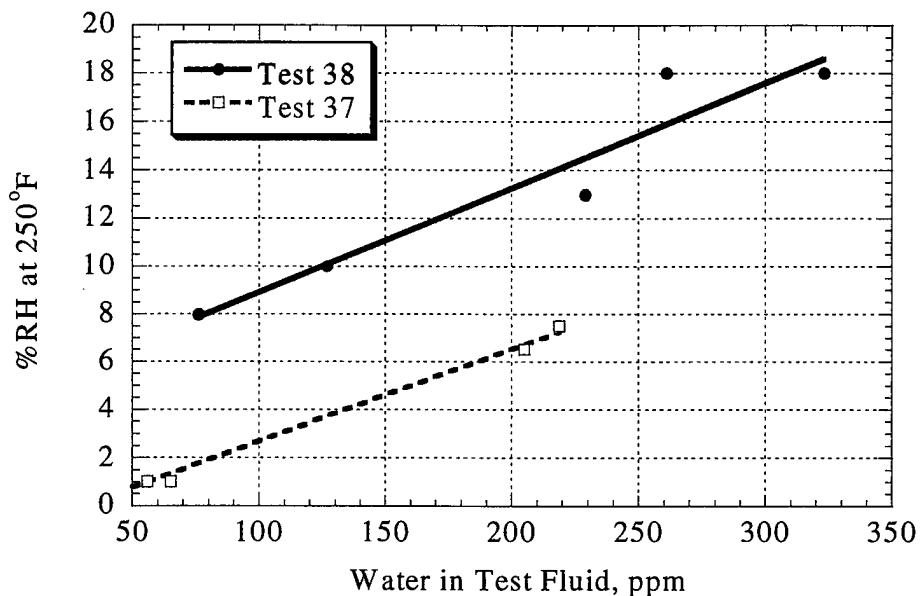


Figure 6. Relative Humidity vs ppm Water in Test Fluid

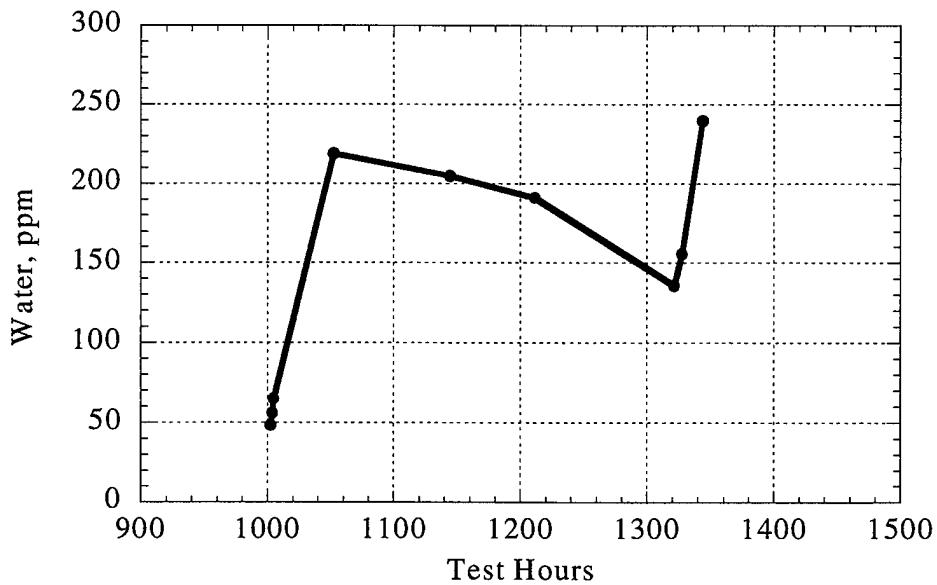


Figure 7. Water in the Test-37 Fluid

A significant event occurred at 1217 hours. The case-drain-flow abruptly jumped by 0.4 gpm. Motor torque spiked by 20 in-lbf but quickly settled down to a value of ~5 in-lbf above the previous value (see Figure. 8). Case pressure also increased by 7 psi and had to be adjusted down to the normal range of 95-105 psig. At 1268 hours, the test experienced its first automatic shutdown on high case-drain temperature (257 °F). After this, the pump started to make a new high-frequency noise, and the case-drain flow started to fluctuate as shown in Figure 9.

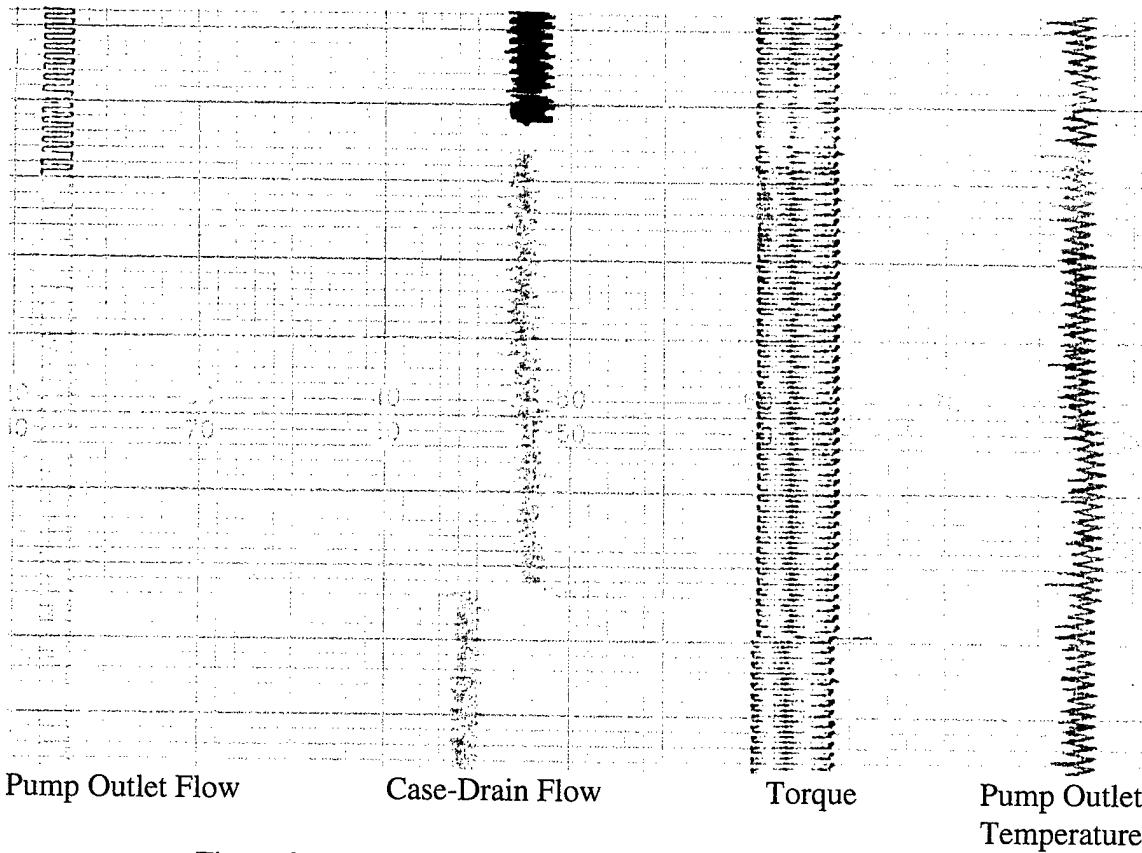


Figure 8. Test 37, Test parameters at ~ 1217 hours

After 1321 hours, the test was stopped to inject more water in the test stand to bring up the moisture content to ~300 ppm. After 1343 hours the test shut down automatically due to high case-drain fluid temperature. The post test inspection showed extensive wear/spalling of the barrel roller bearing and the race. The internal drive-shaft bearing rotated freely and seemed to be in good shape. The piston hanger assembly was disassembled at McClellan AFB. Piston shoes appeared worn down a little. Piston shoe clearance was measured to be 0.0054 inch. The design piston shoe clearance is 0.0040. The thrust washer showed considerable wear.

From the above events it appears that the barrel bearing failure started around 1217 hours and progressed rapidly. Fluctuations in the case-drain flow and temperature are an

indication of the barrel face not running true with the valve-plate. Increase in the pump noise could be due to the added metal-metal interaction between the rollers and races of the barrel bearing.

The test parameters change throughout the 60-second cycle as shown in Figures 8 and 9. The case-drain flow and the viscosity of the fluid samples are shown in Figures 10 and 11.

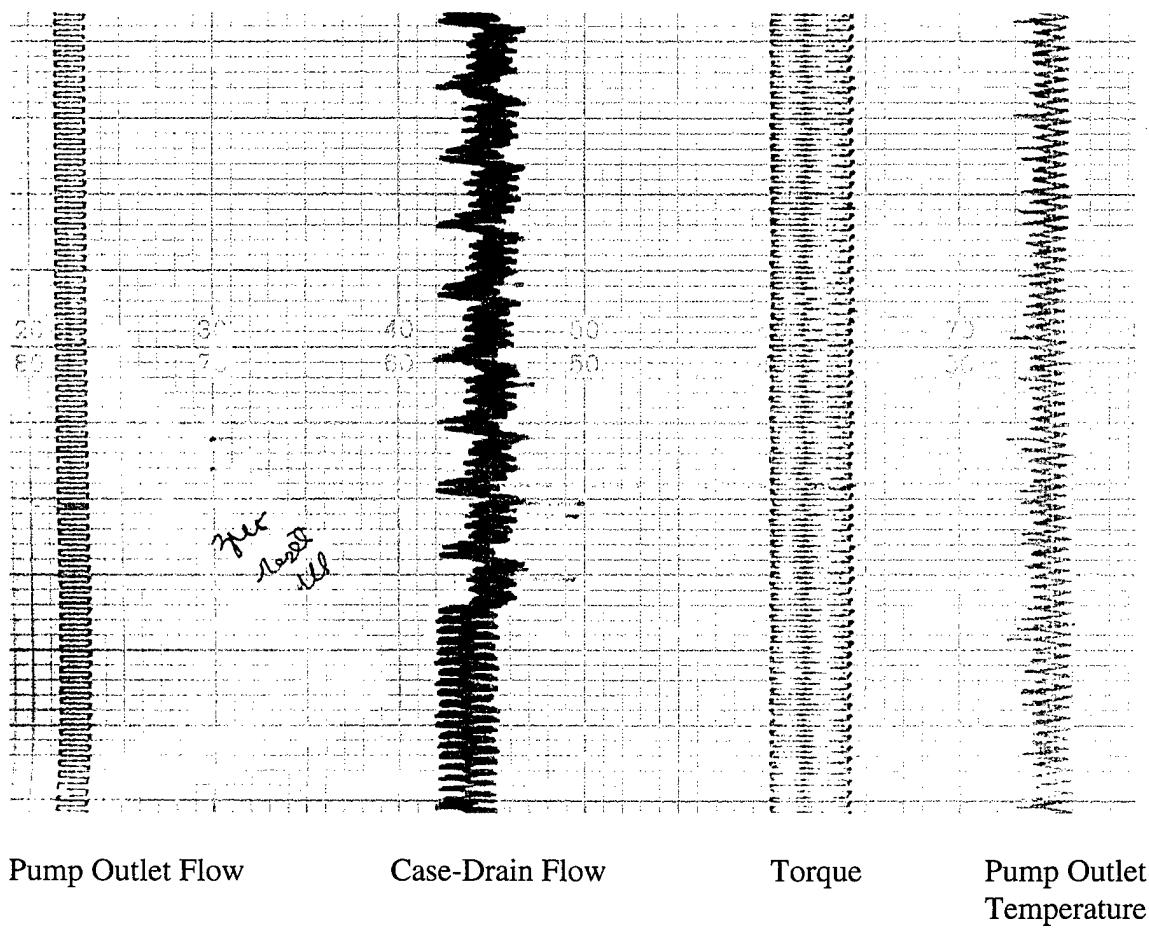


Figure 9. Test 37, Test parameters at ~ 1319 hours

The scatter in the case-drain flow is a result of the different times during the 60-second interval when the data-acquisition captures the data. The average case-drain flow increased throughout the test, but became more erratic towards the end of the test.

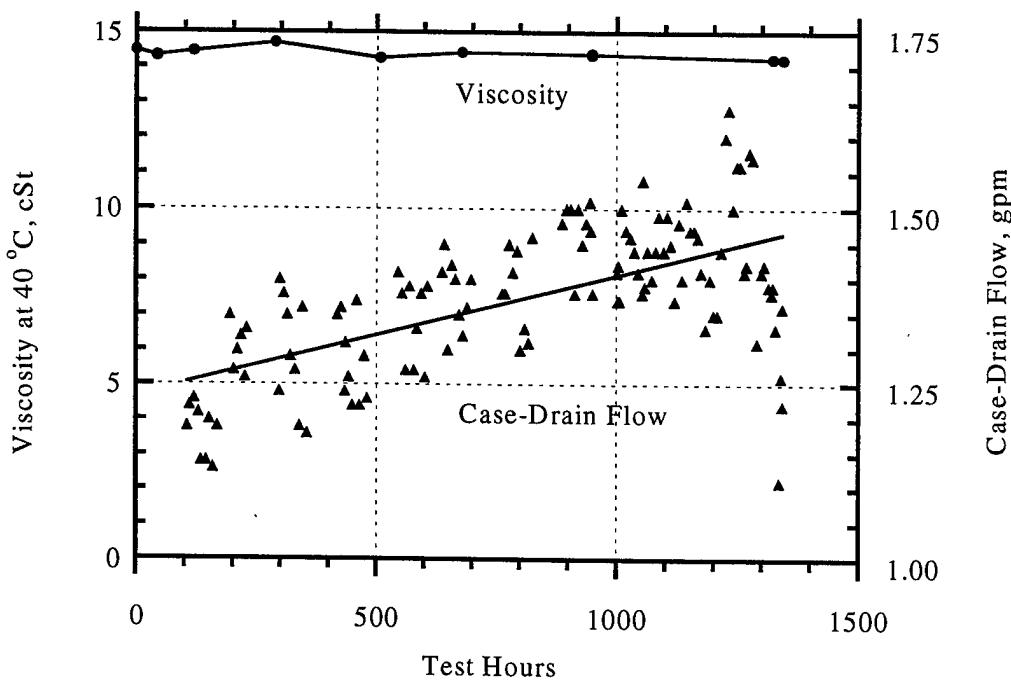


Figure 10. Case Drain Flow and Viscosity for Test 37 with Fresh MIL-PRF-83282, Throttle Valve Closed

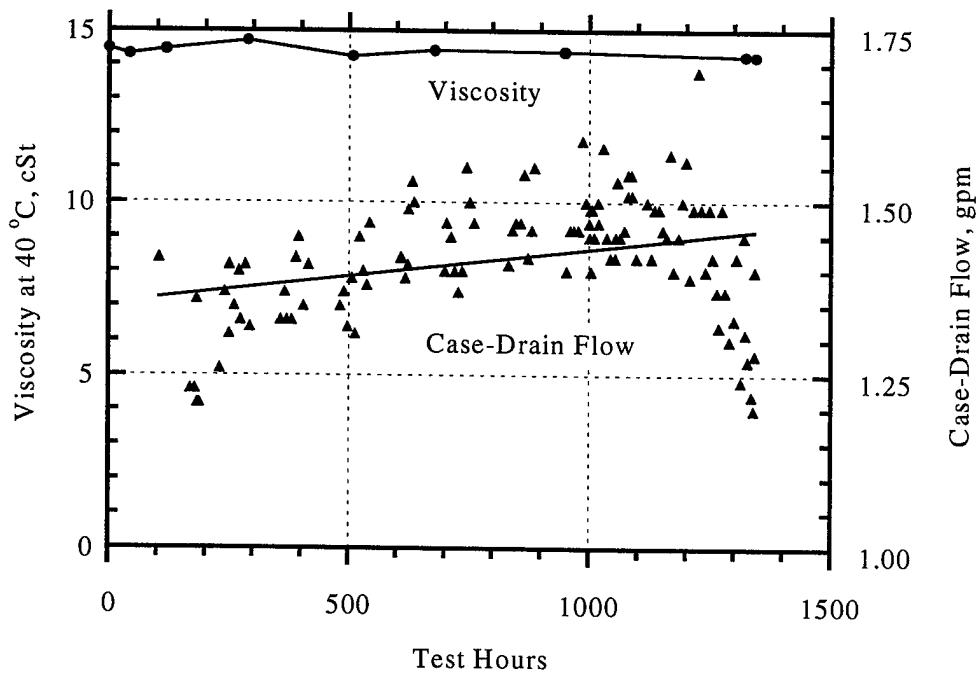


Fig. 11. Case Drain Flow and Viscosity for Test 37 with Fresh MIL-PRF-83282, Throttle Valve Open

## 4.2 PUMP TEST WITH PURIFIED MIL-PRF-83282 (Test 38)

The pump test with purified MIL-PRF-83282 fluid was carried out as per the test plan in 3.1. Stage I of the test with purified fluid was completed successfully. At 954 hours, the test was stopped to inspect the pump. The pictures taken before the test, after 954 hours and after the completion of the test are shown in Appendix-B. The piston hanger assembly was not disassembled. Polishing wear was observed on most of the pump parts. Otherwise, the pump looked to be in good condition.

The pump was re-assembled and installed on the test stand for Stage II testing. Distilled water was injected into the reservoir in increments until the total amount of water in the test fluid was ~300 ppm. The water content in the fluid was continuously monitored by a relative humidity sensor, and it was also measured in the periodic fluid samples. The measured water content was proportional to the % relative humidity measured by the RH-sensor, as shown in Figure 6, but the RH reading was much higher than in Test 37. It is suspected that the RH sensor malfunctioned or needed re-calibration. As the test progressed, the water content in the test fluid declined (see Figure 12) as observed in Test 37. After 1236 hours, the water content in the test fluid had dropped to 127 ppm (see Table 2 and Figure 12). The test was stopped and additional distilled water was added to bring up the moisture content in the test fluid to 261 ppm.

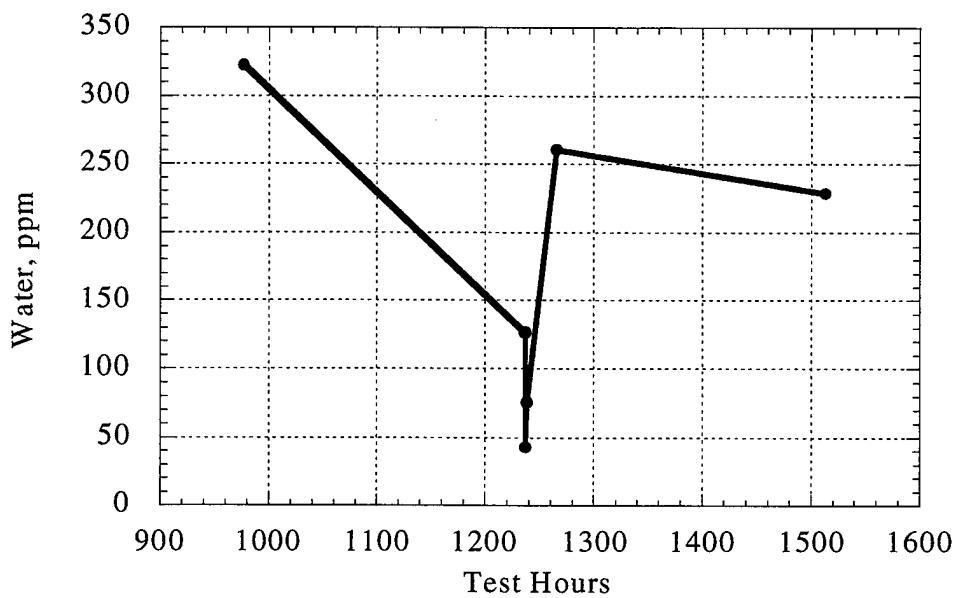


Figure 12. Water in the Test-38 Fluid

After 1400 hours, events leading to the failure of the pump started. At 1403 hours, the case-drain temperature increased by 3 °F, stayed there for six minutes and then slowly

returned to normal. The case-drain flow and pressure also increased. Until the end of the test, the case-drain pressure had to be manually adjusted several times to keep it within limits. After 1475 hours, additional noise was observed on the pump outlet flow signal (see Figure 13). After 1500 hours, the case-drain flow started to fluctuate as shown in Figure 14. These instabilities are attributed to the impending shaft-bearing failure. When the shaft bearing is spalled, the gap between the cylinder-block/valve-plate interface varies leading to the fluctuations in the case-drain and the pump outlet flow.

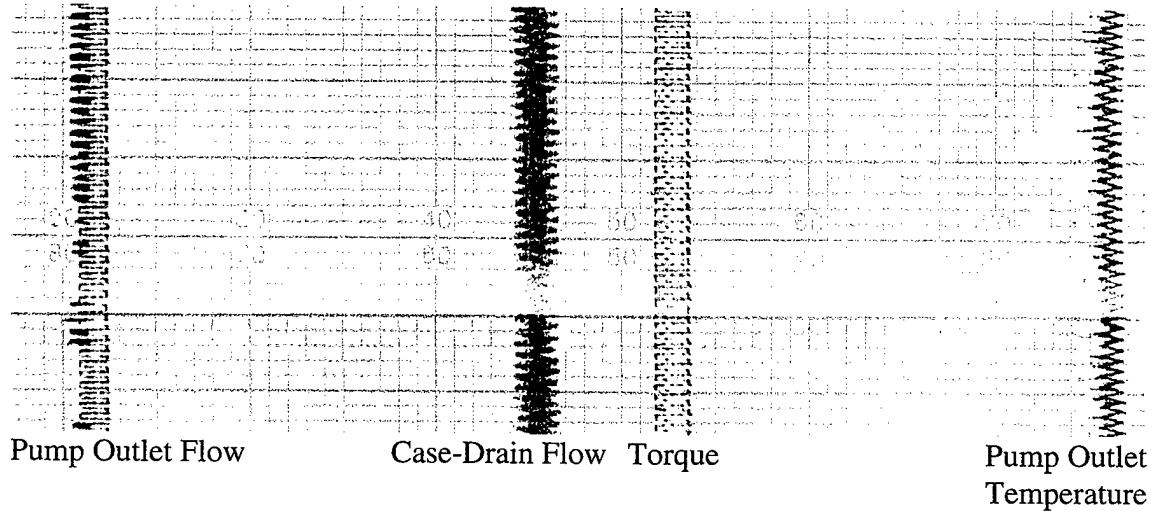


Figure 13. Test 38, Test parameters at  $\sim 1475$  hours

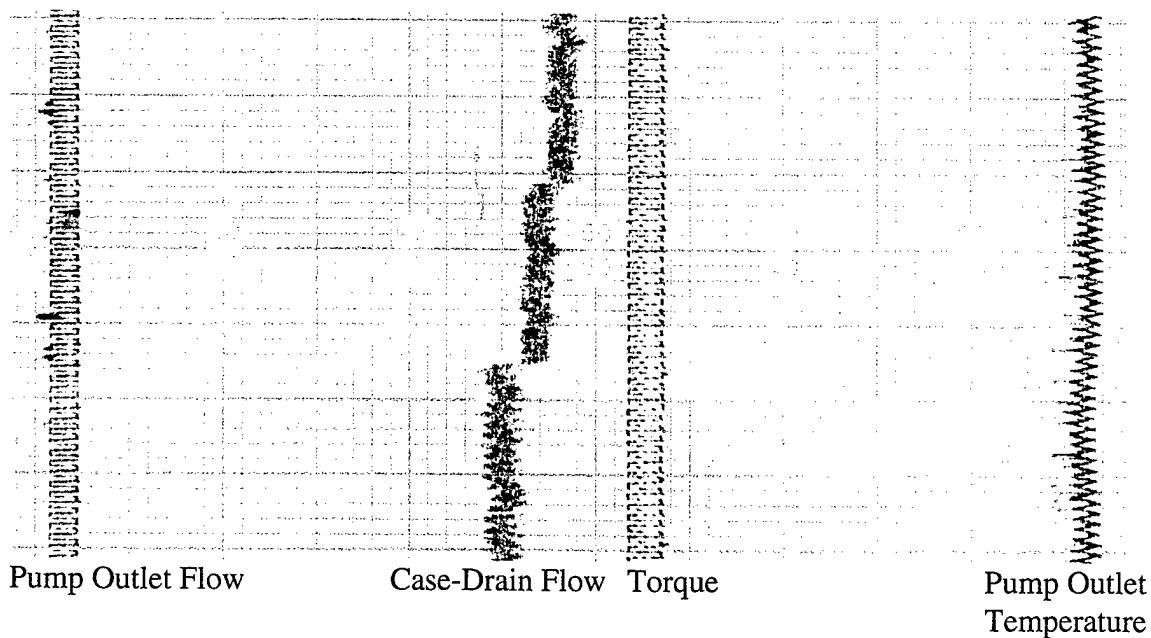


Figure 14. Test 38, Test parameters at  $\sim 1500$  hours

After 1513 hours the test shut down automatically due to high case-drain fluid temperature. The post test inspection showed extensive wear/spalling of the internal drive-shaft bearing and the barrel roller bearing. The piston hanger assembly was disassembled at McClellan AFB. The wear between shoes and wear plate was slightly tapered. A 0.010" thick feeler gauge would start very easily, but failed to go less than half way through, whereas a 0.007" feeler gauge made it all the way through. There was still sufficient bronze coating left on the shoe faces for many hours of operation. A complete removal of the bronze plating from the shoe faces would result in steel-steel contact between the piston-shoe and the bearing plate. This could result in higher heat generation in the pump and lead to an early failure. Wear patterns on thrust washer showed debris travelling through the system, but seemed to still be within tolerance. There appeared to be a material transfer from the piston shoes to the wear surface on the hanger and pistons to the barrel bores. The hanger wear surface had some pitting at the beginning of the down stroke of the pistons. Some wear was also observed on the hanger bearings.

The case-drain flow and the viscosity of the fluid samples are shown in Figures 15 and 16. Like Test 37, the average case-drain flow increased throughout the test. The viscosity of the fluid did not change during the test.

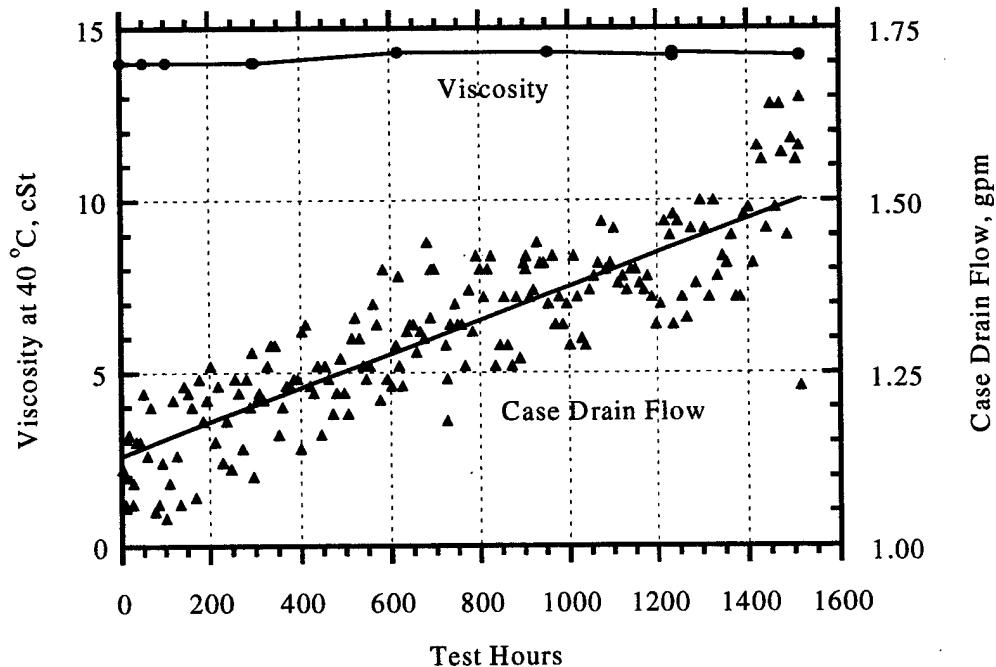


Fig. 15. Case Drain Flow and Viscosity for Test 38 with Purified MIL-PRF-83282, Throttle Valve Closed

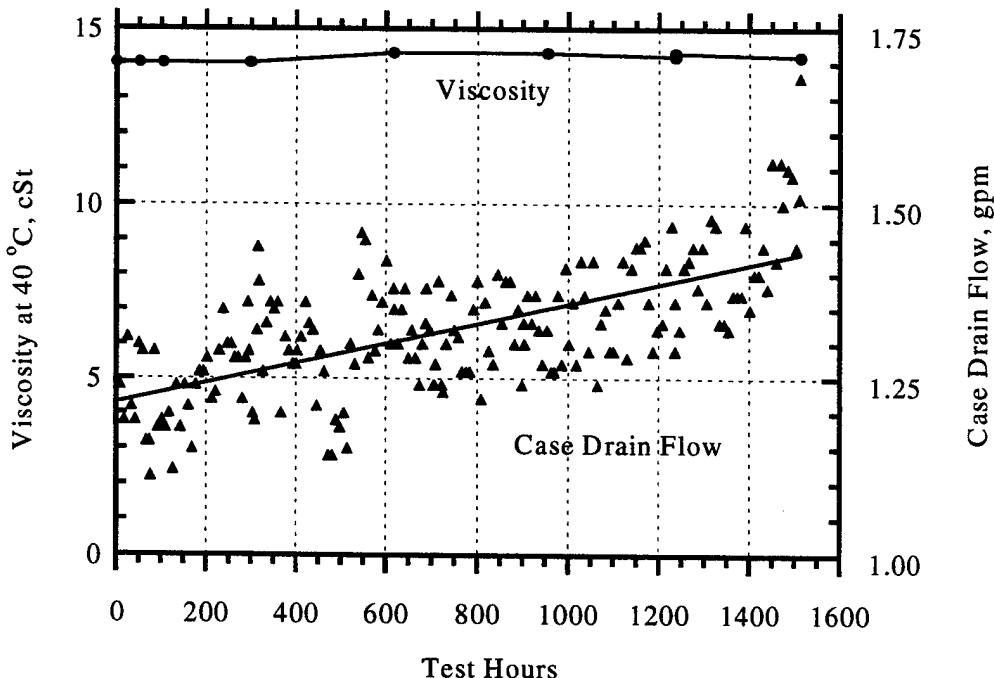


Fig. 16. Case Drain Flow and Viscosity for Test 38 with Purified MIL-PRF-83282, Throttle Valve Open

#### 4.3 ANALYSES OF THE FLUID SAMPLES

A number of fluid samples were analyzed for the following:

1. Viscosity
2. Acid Number
3. Water Content
4. Lubricity (4 Ball Wear Test)
5. Metal Content
6. Foaming

The tests were performed to determine differences, if any, in the functioning of the fluid caused by the Pall purifier. It was assumed the purifiers do effectively clean the fluid, as this has been demonstrated in other purifier tests. Areas of concern were in possible removal of the antiwear additive, tricresylphosphate, and in possible increase in foaming tendency caused by removal of antifoam additives. During the pump tests, fluid samples were extracted from the operating test stand as the testing progressed. These samples were taken at the approximate intervals listed in Section 3.1. A number of different analyses were conducted on these samples (see Tables 2 and 3).

Water content and acid numbers of the fluid samples were determined and are shown in Tables 2 and 3. Data are very similar.

After the introduction of water into the test fluid (during Stage II), the acid number of the fluid increased. For Test-37, the acid number after 1321.4 hours had increased to 2.3. A similar increase was observed for Test-38. The interaction of water and the fluid/additives generated some acidic products. The increase in the acid number did not affect the anti-wear properties of the fluid as seen from the 4-ball tests. A few samples from both the tests were evaluated for lubricity by 4-ball wear testing according to ASTM Method D-4172. No differences were seen between the two pump tests.

Trace metal analysis was also performed on the fluid samples from the purifier pump test. The samples were analyzed for 19 elements including Fe, Ag, Cr, Cu, Mg, Na, Ni, Pb, Si, Sn, Ti, Ba, Cd, Mn, Mo, V, and Zn. Only those elements which show concentrations above 0.1 ppm. are reported in Tables 2 and 3. No abnormalities were observed.

Foaming was measured in samples from the purifier test. No increase in foaming was observed.

Table 2. Fluid Characteristics – Samples from Test 37 with Fresh MIL-PRF-83282

MLO	TEST HOURS	Acid Number mg KOH/g	KF Water (ppm)	Vis@40°C (cSt)	Four-Ball		ICP (ppm)					
					Run 1	Run 2	Fe	Zn	Cu	Pb	Ba	Na
Specification limits		0.2	100 max		0.65 max							
97-322	0.0		113	14.47	0.66	0.60	b	b	b	b	b	b
98-17	41.7		135	14.31	0.57	0.63	b	b	b	b	b	b
98-18	117.8		152	14.44	a	a	b	b	b	b	b	b
98-19	287.4		146	14.70	a	a	b	b	b	b	b	b
98-20	506.8		132	14.25	a	a	b	b	b	b	b	b
98-28	677.8		82	14.43	0.43	0.43	b	b	b	b	b	b
98-34	947.9		56	14.39	0.47	0.47	b	b	b	b	b	b
98-80	1321.4	2.3	136	14.26	0.42	0.43	1	1	b	b	b	2
98-82	1343.4		240	14.24	0.37	0.43	4	4	b	b	b	1

a = not determined

b = not detectable

Table 3. Fluid Characteristics – Samples from Test 38 with Purified MIL-PRF-83282

MLO	TEST HOURS	Acid Number mg KOH/g	KF Water (ppm)	Vis@40°C (cSt)	Four-Ball		ICP (ppm)				
					Run 1	Run 2	Fe	Zn	Cu	Pb	Ba
Specification limits		0.2	100 max		0.65 max						
98-196	0.0	0.0	84	14	0.44	0.45	a	a	a	a	a
98-197	50.8	a	135	14	0.43	0.43	a	a	a	a	a
98-198	104.2	a	127	14	0.38	0.43	a	a	a	a	a
98-199	297.6	a	119	14	0.43	0.43	a	a	a	a	a
98-200	298.2	a	50	14	0.51	0.43	a	a	a	a	a
98-201	616.7	0.22	109	14.3	0.45	0.45	b	b	b	b	b
98-202	616.7	a	37	14.3	0.40	0.44	b	b	b	b	b
98-203	953.9	a	62	14.3	0.43	0.42	b	b	b	b	b
98-204	953.95	a	52	14.3	0.43	0.45	b	b	b	b	1
98-205	976.55	0.36	323	a	a	a	a	a	a	a	a
98-206	1236.46	2.18	127	14.2	0.43	0.43	b	1	b	b	4
98-207	1236.46	1.88	43	14.3	0.41	0.42	b	2	b	b	3
98-208	1237.58	1.98	76	a	a	a	a	a	a	a	a
98-209	1265.2	2.44	261	a	a	a	a	a	a	a	a
98-210	1513	3.23	229	14.2	0.38	0.39	1	3	b	b	2

a = not determined

b = not detectable

#### 4.4 PERFORMANCE COMPARISON

The failure modes were similar for both the tests. In Test 37, the barrel-bearing failed after 1343 hours whereas, in Test 38 both the shaft-bearing and the barrel-bearing failed after 1513 hours. Failure of one bearing can lead to an early failure of the other bearing. Bearing failures in both the tests were detected by a sudden increase in case-drain temperature. The differences in the bearing lives from the two tests are not significant. Rolling element bearings, made out of AISI 52100 steel, seem to be the weak link in the F-16 main hydraulic pump. The pump life may be considerably increased by the use of better bearing material such as M50 steel. In previous pump tests in this laboratory, the pump life increased at least two-fold after the AISI 52100 bearing was replaced with an M50 bearing [5].

Wear patterns on other surfaces were similar. Severe cavitation was not observed on any of the parts in either test.

The case-drain flow gradually increased with time during both tests. Fluctuations in the case-drain flow were observed towards the end of both tests.

Viscosity of MIL-PRF-83282 did not change throughout both the tests. This was expected, as there are no viscosity-index improving additives to shear in MIL-PRF-83282.

## 5.0 CONCLUSIONS

5.1 Endurance pump tests with both fresh and purified MIL-PRF-83282 were conducted using the F-16 main hydraulic pump. There was no apparent difference in pump performance with either fluid. The fluid purifier did not adversely affect the pump life.

5.2 Rolling element bearings seem to be the weak link in the F-16 main hydraulic pump.

## 6.0 REFERENCES

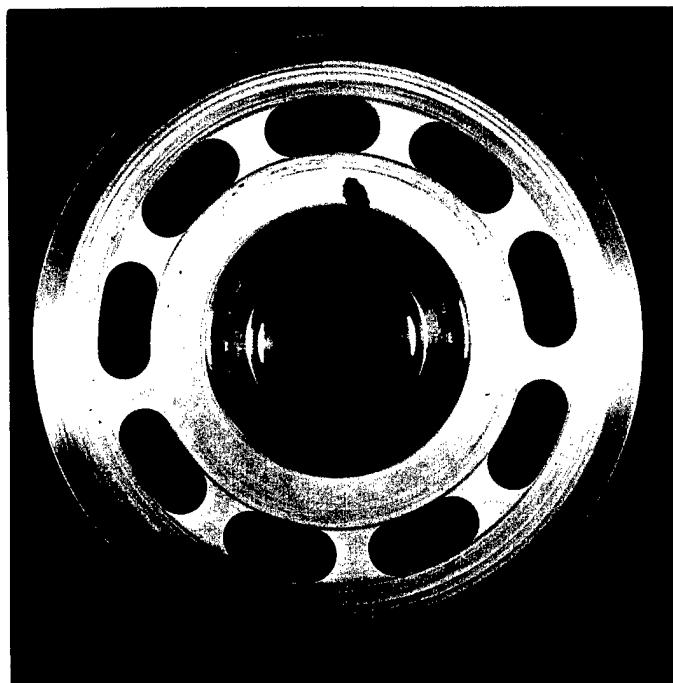
1. Snyder, C.E., Jr., Gschwender, L.J., and Schenach, T.A., "Recycling of MIL-H-5606 and MIL-H-6083 Mineral Based Hydraulic Fluids," Lubrication Engineering, 40, 667-671 (1984).
2. Purdey, E. M., Rutkowski, D. M., and Sterting, F. D., "Recycling MIL-H-46170 Hydraulic Fluid to Extend Fluid Service Life," US Army, TARDEC Technical Report #13619 (March 1995).
3. Sharma, S.K., Snyder, C.E., Jr., Gschwender, L. J., Cecere, G.J., and Jenney, T.A., "Endurance Pump Tests with Fresh and Purified MIL-H-5606 Hydraulic Fluid," US Air Force Technical Report AFRL-ML-WP-TR-1998-4211 (June 1998).
4. Gschwender, L. J., Snyder, C.E., Jr. and Sharma, S.K., "Pump Evaluation of Hydrogenated Polyalphaolefin Candidates for a -54°C to 135°C Fire-Resistant Air Force Aircraft Hydraulic Fluid," Lubrication Engineering, 44, 4, 324-329 (1988).
5. Gschwender, L. J., Snyder, C.E., Jr. and Sharma S.K., "Development of a -54°C to 175°C High Temperature Nonflammable Hydraulic Fluid for Air Force Systems," Lubrication Engineering, 49, 8, 621-630 (1993).

## 7.0 ACKNOWLEDGMENTS

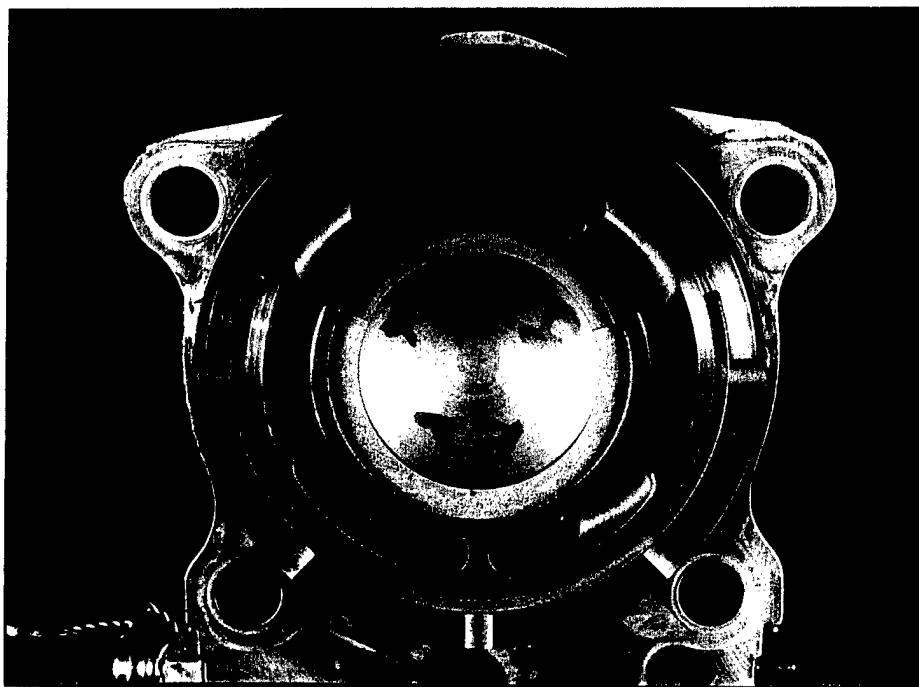
1. OO-ALC Hill AFB (POC: Capt. Troy Denhardt) for providing the funding for this project
2. William Keim, McClellan AFB for providing the test pumps and for helping with the disassembly and inspection of the piston-hanger assembly
3. Eglin and Tyndall AFB for providing the Pall purifier.
4. University of Dayton Research Institute for fluid analyses
5. Mr. Vince Vidoni, University of Dayton Research Institute for photographing the pump parts

## APPENDIX-A

Photos From Pump Test With MIL-PRF-83282 (Test 37)

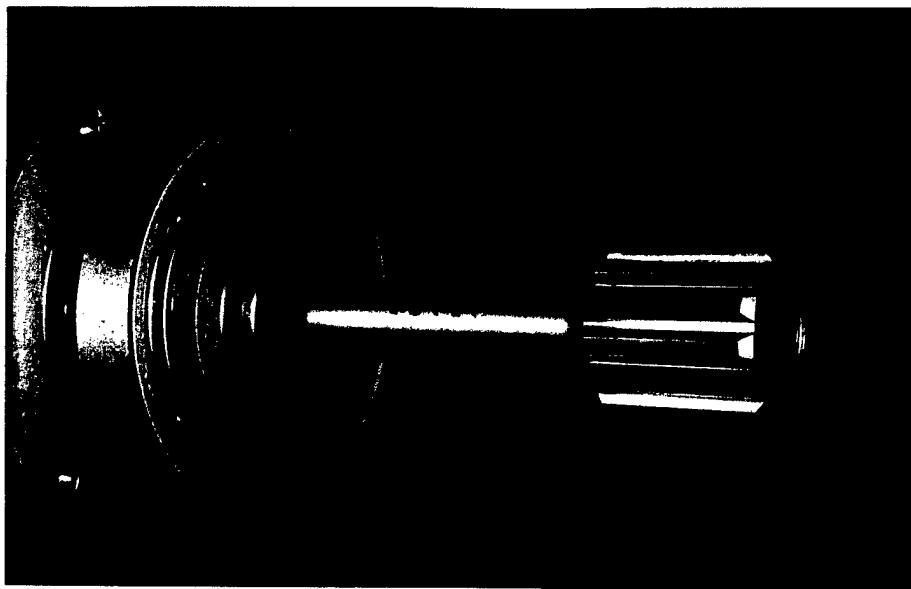


Cylinder Block Face

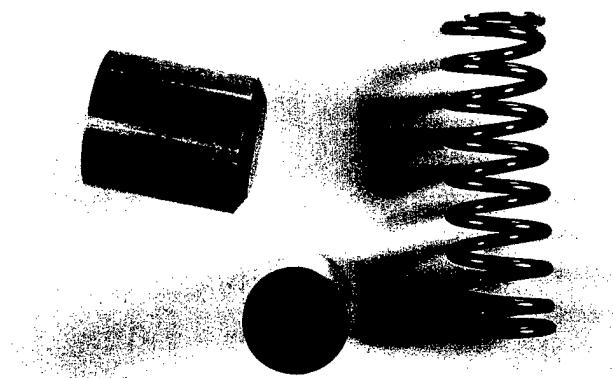


Valve Plate

Cylinder Block Face and Valve Plate at Pretest  
Pump Test 37 with MIL-PRF-83282

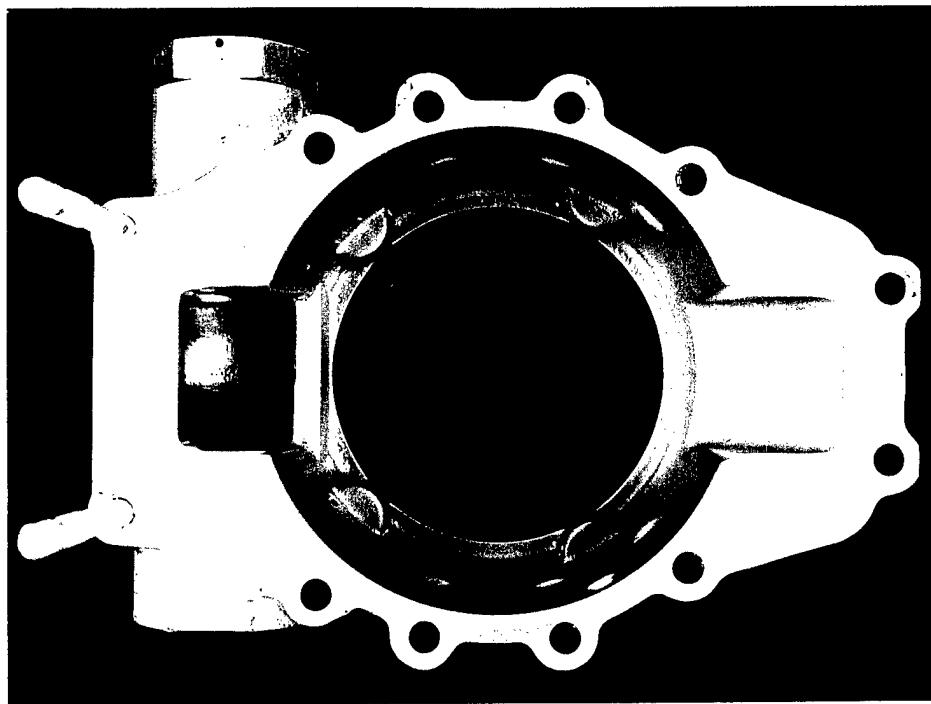


Internal Drive Shaft

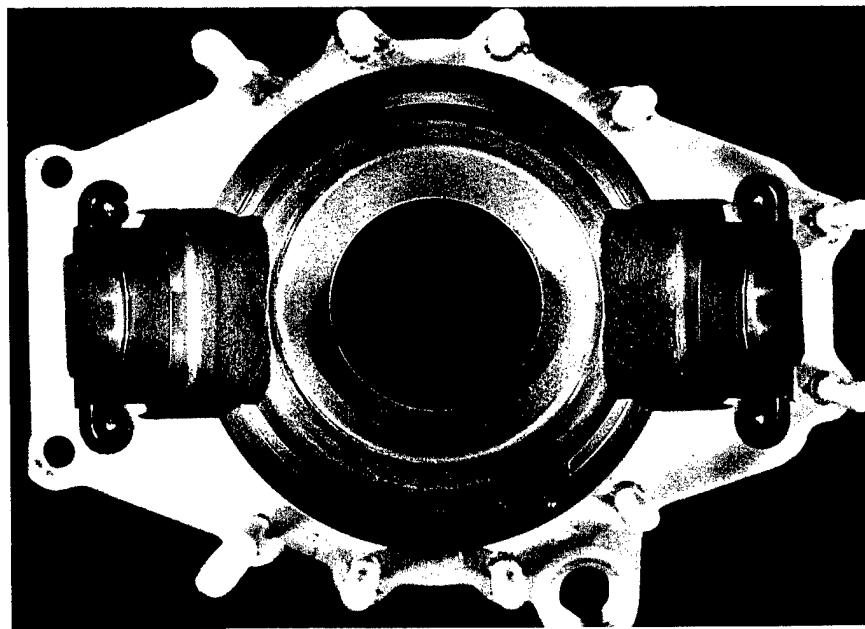


Actuator Pistons and Spring

Internal Drive Shaft and Pump Components at Pretest  
Pump Test 37 with MIL-PRF-83282

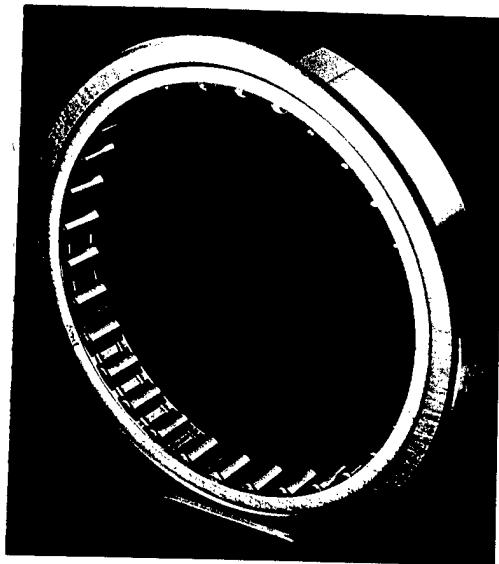


Housing – Front Side

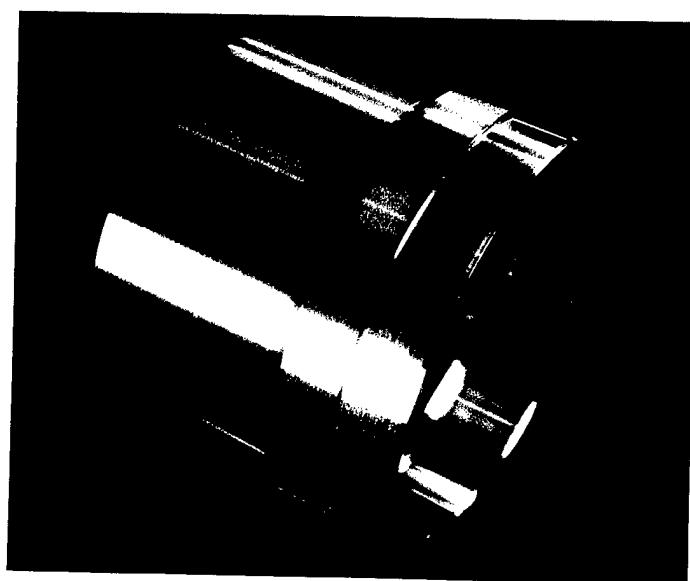


Housing – Back Side

Housing at Pretest  
Pump Test 37 with MIL-PRF-83282

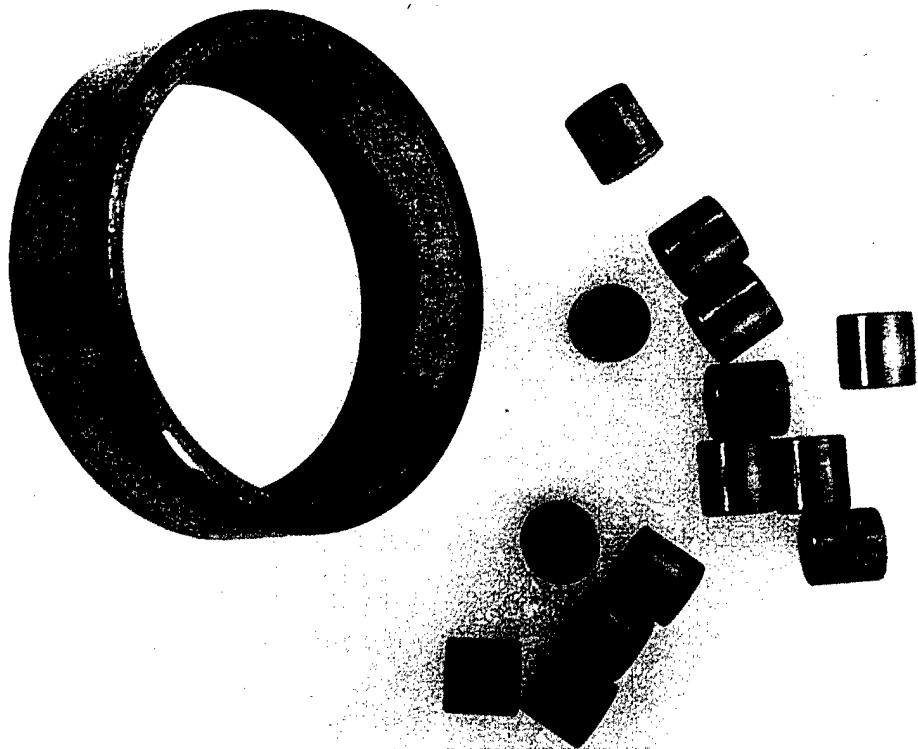


Barrel Roller Bearing

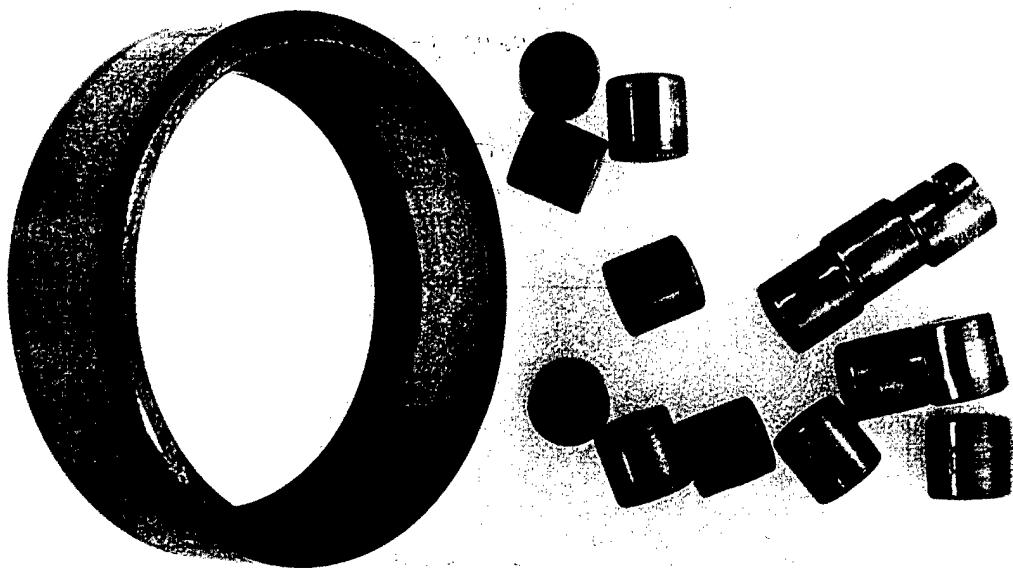


Barrel Bearing Race

Barrel Roller Bearing and Barrel Bearing Race at Pretest  
Pump Test 37 with MIL-PRF-83282

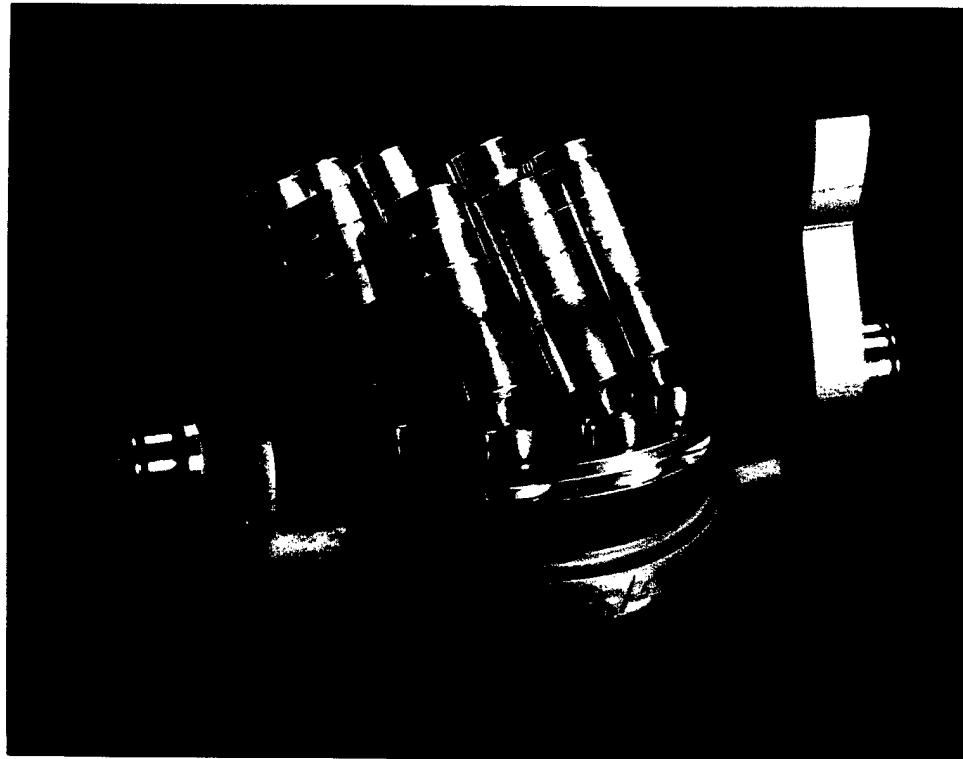


Hanger Bearing, Arm Side



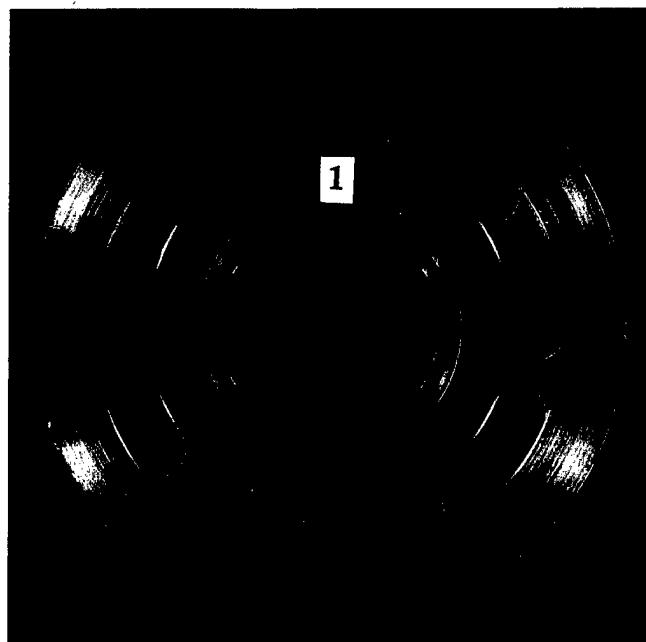
Hanger Bearing, Non-Arm Side

Hanger Bearings and Retainers at Pretest  
Pump Test 37 with MIL-PRF-83282



Hanger and Piston Subassembly

Hanger and Piston Subassembly at Pretest  
Pump Test 37 with MIL-PRF-83282

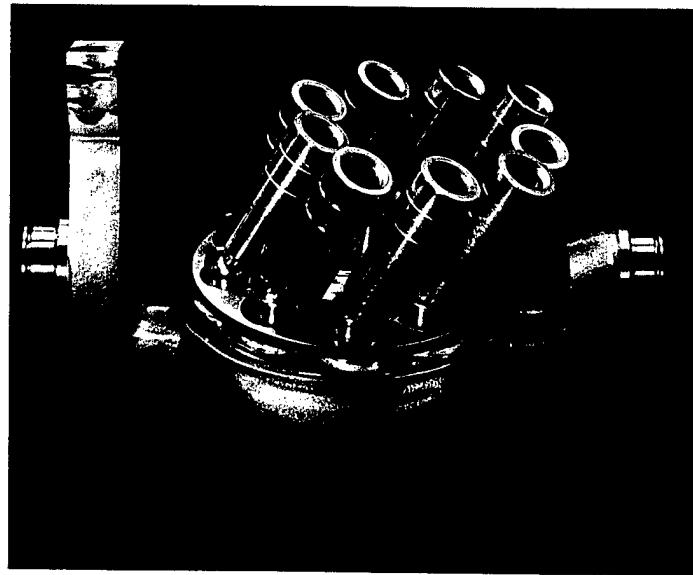


Cylinder Block Face

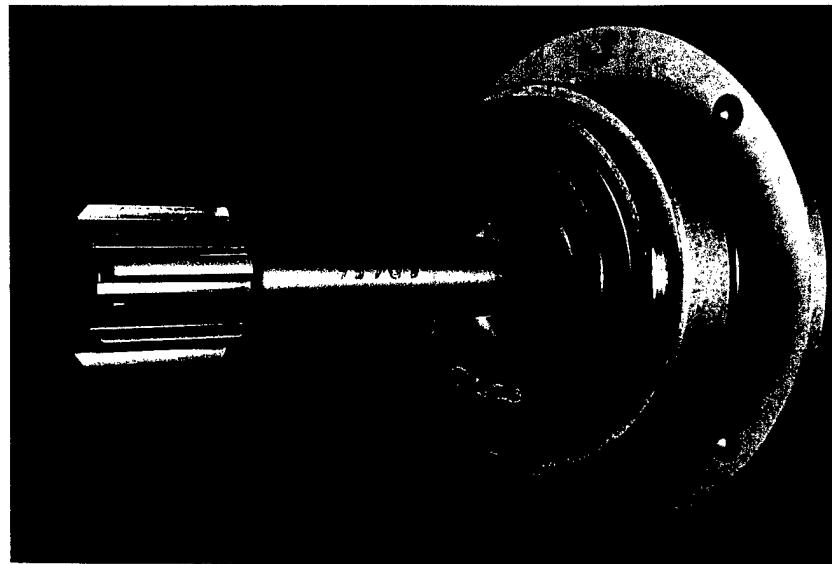


Valve Plate

Cylinder Block Face and Valve Plate at 1000 Hours  
Pump Test 37 with MIL-PRF-83282

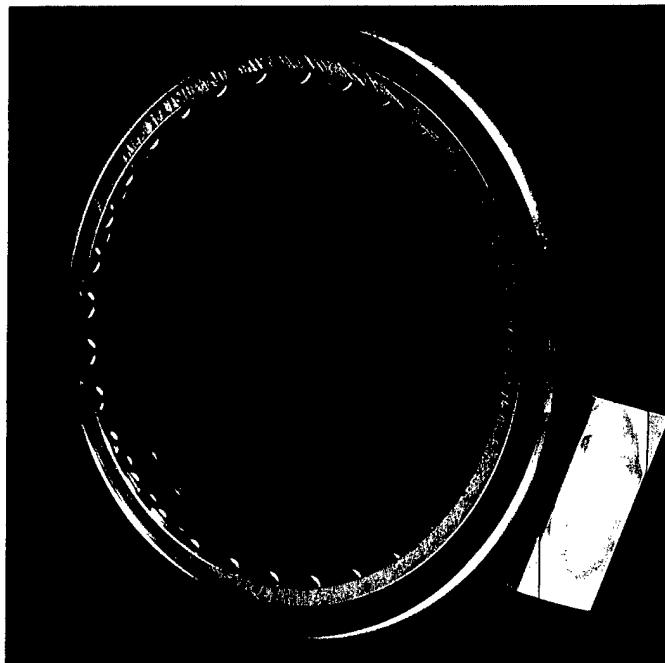


Hanger and Piston Subassembly

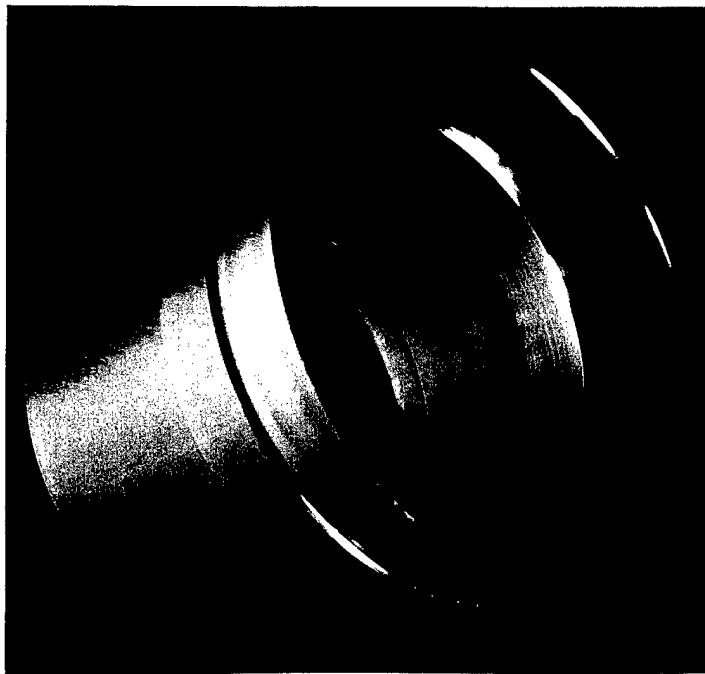


Internal Drive Shaft

Hanger and Piston Subassembly and Internal Drive Shaft at 1000 Hours  
Pump Test 37 with MIL-PRF-83282

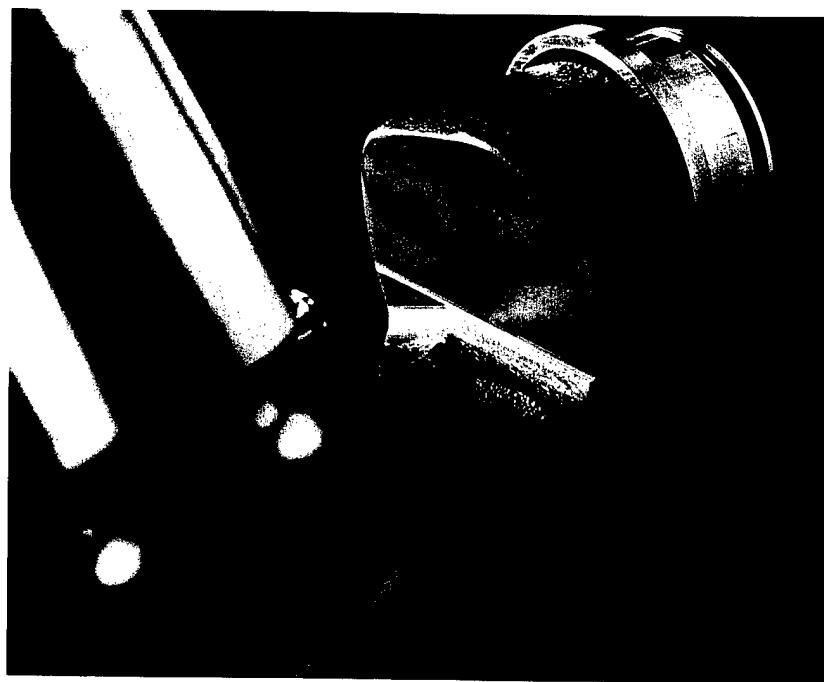


Barrel Roller Bearing



Barrel Bearing Race

Barrel Roller Bearing and Barrel Bearing Race at 1000 Hours  
Pump Test 37 with MIL-PRF-83282

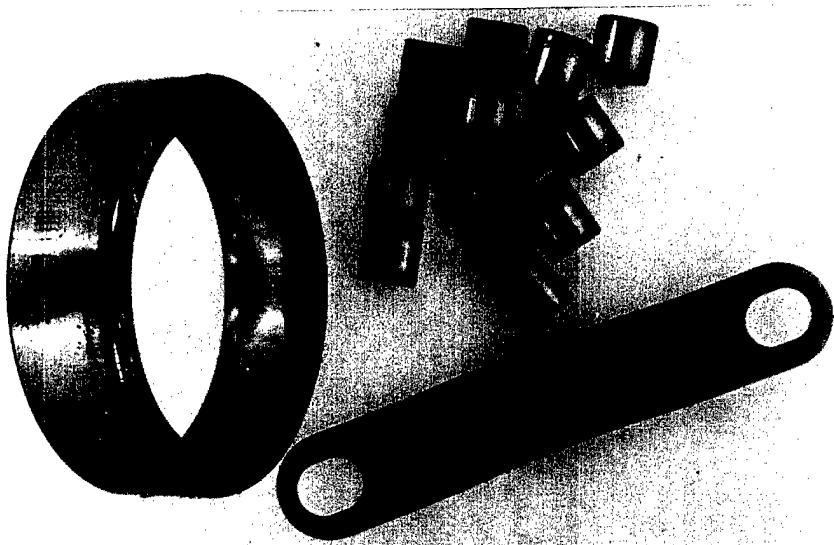


Hangar, Non-Arm Side

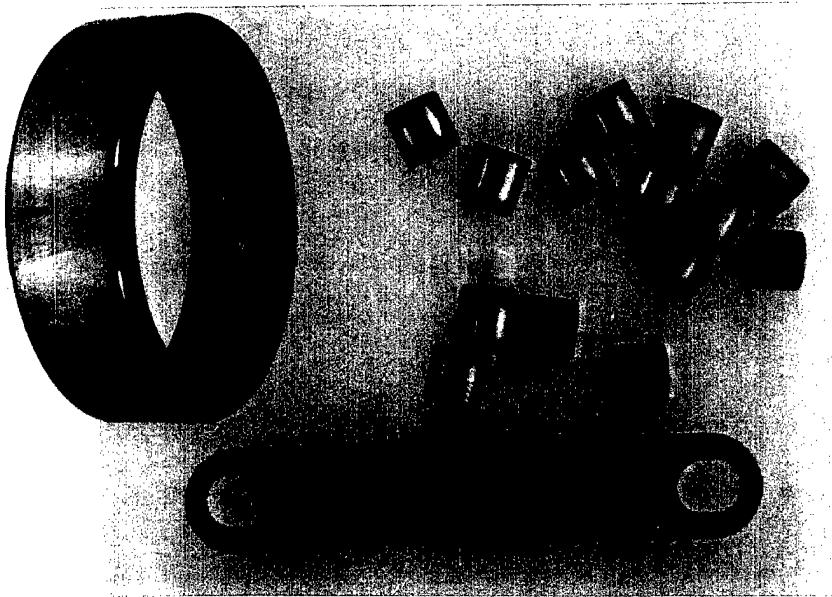


Hanger, Arm Side

Hanger at 1000 Hours  
Pump Test 37 with MIL-PRF-83282



Hanger Bearing and Retainer, Arm Side

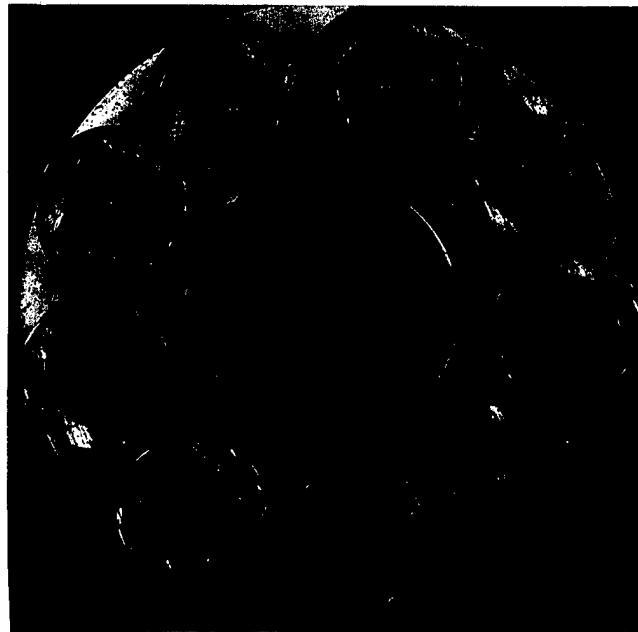


Hanger Bearing and Retainer, Non-Arm Side

Hanger Bearings and Retainers at 1000 Hours  
Pump Test 37 with MIL-PRF-83282

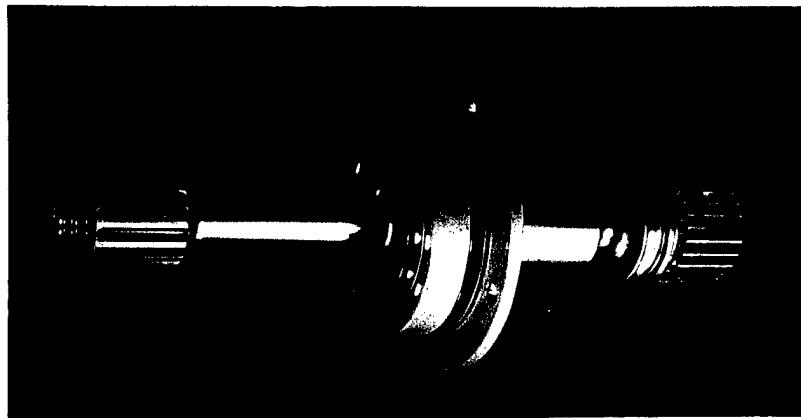


Cylinder Block Face

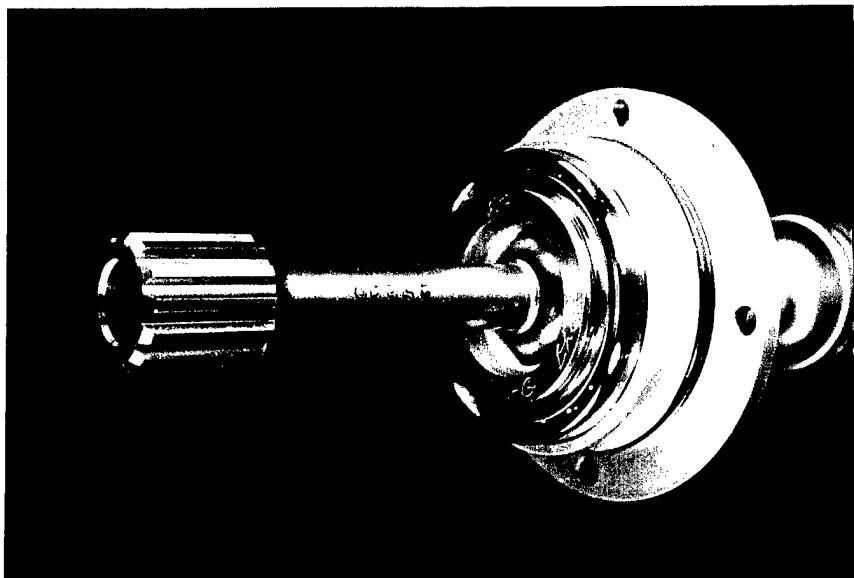


Piston Shoe Faces

Cylinder Block Face and Piston Shoe Faces at 1343 Hours  
Pump Test 37 with MIL-PRF-83282

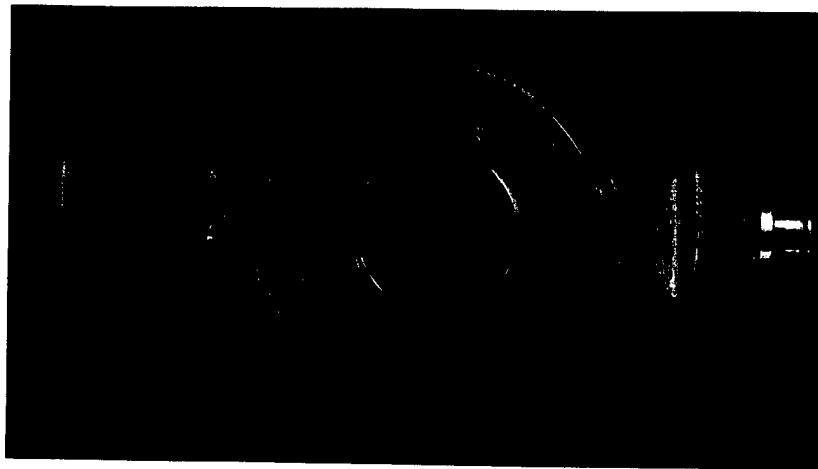


Internal Drive Shaft

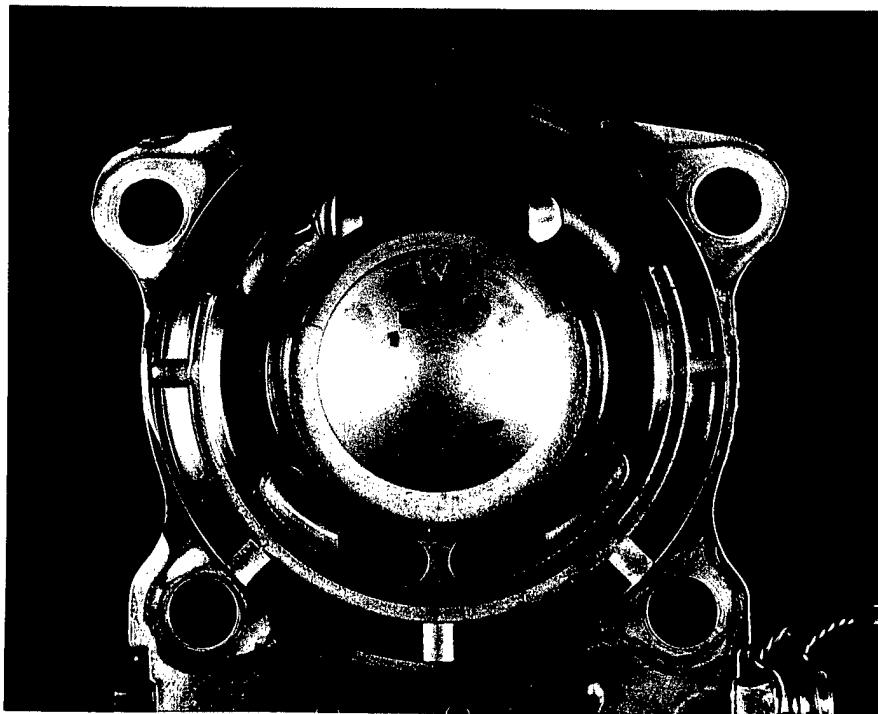


Enlargement of Internal Drive Shaft

Internal Drive Shaft at 1343 Hours  
Pump Test 37 with MIL-PRF-83282

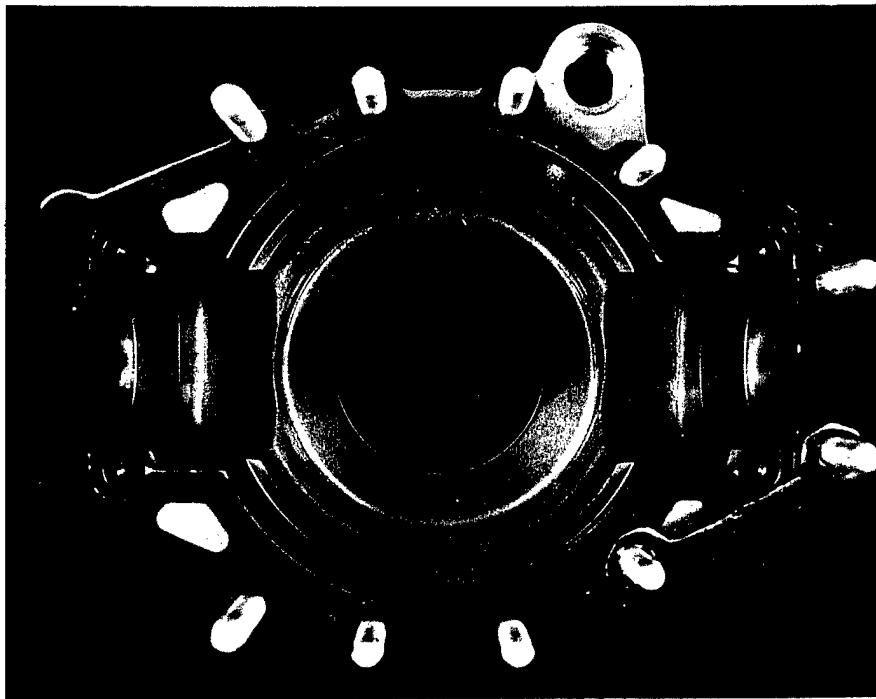


Piston Hanger

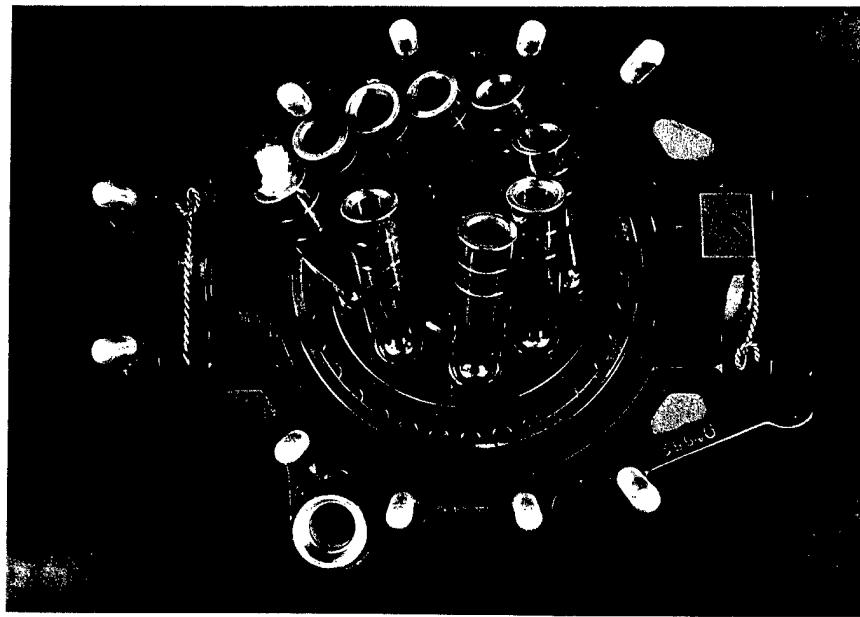


Valve Plate

Piston Hanger and Valve Plate at 1343 Hours  
Pump Test 37 with MIL-PRF-83282

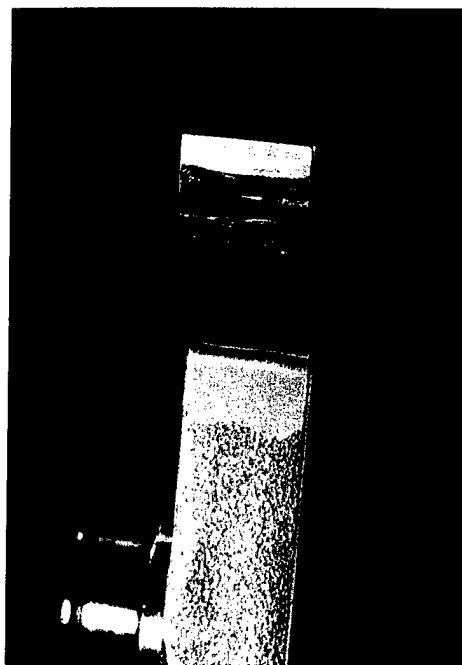


Housing



Partial Piston Assembly

Housing and Partial Piston Assembly at 1343 Hours  
Pump Test 37 with MIL-PRF-83282

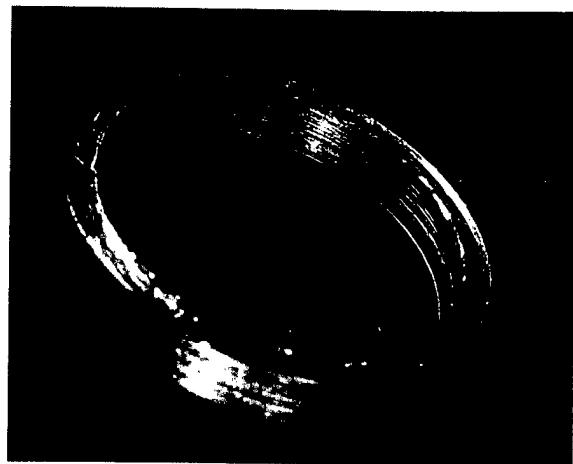


Hanger, Arm-Side

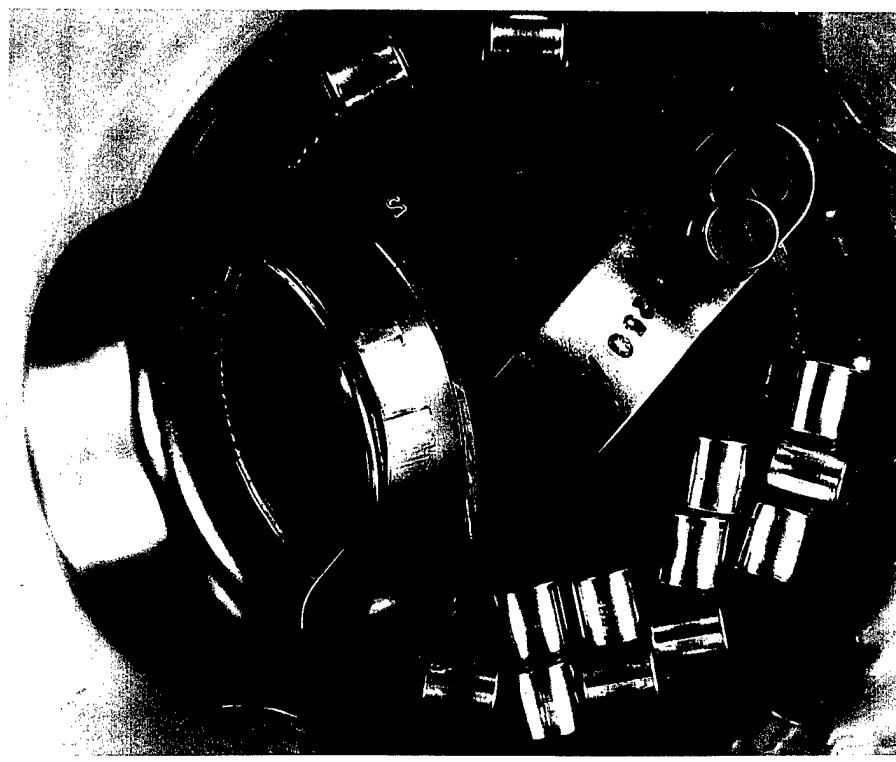


Hanger, Non-Arm Side

Hanger at 1343 Hours  
Pump Test 37 with MIL-PRF-83282

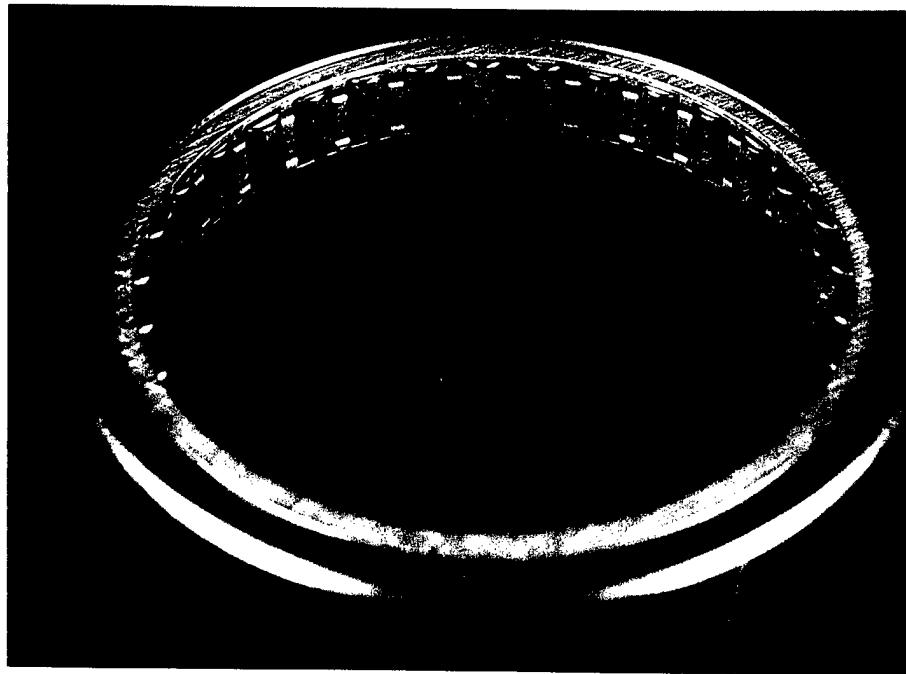


Thrust Washer

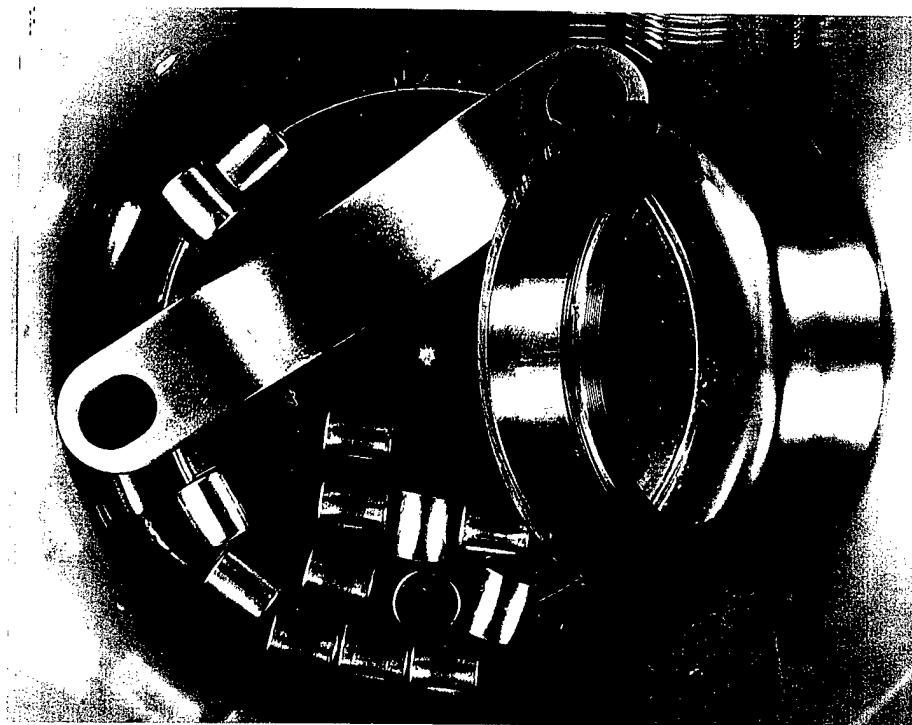


Hanger Bearing and Retainer, Non-Arm Side

Thrust Washer and Hanger Bearing at 1343 Hours  
Pump Test 37 with MIL-PRF-83282



Barrel Roller Bearing



Hanger Bearing and Retainer, Arm Side

Barrel Roller Bearing and Hanger Bearing at 1343 Hours  
Pump Test 37 with MIL-PRF-83282

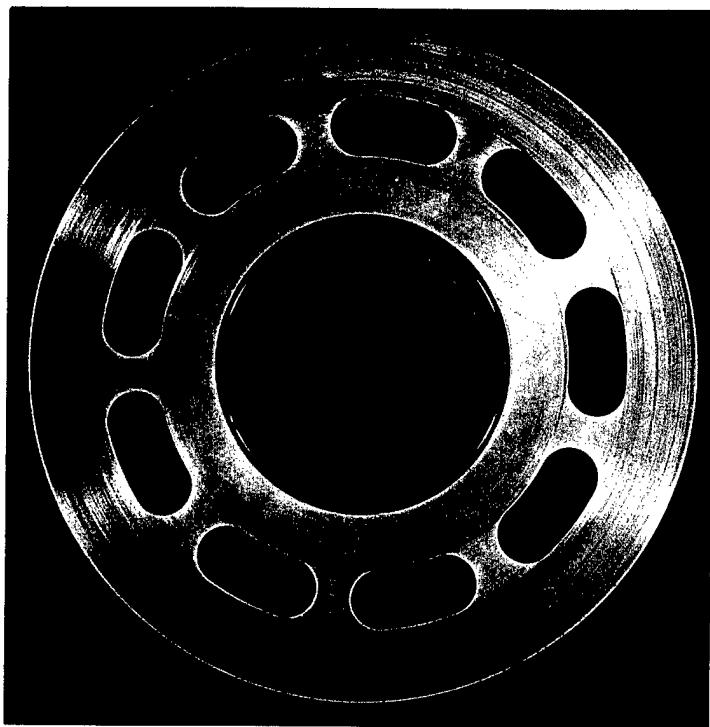


Barrel Bearing Race

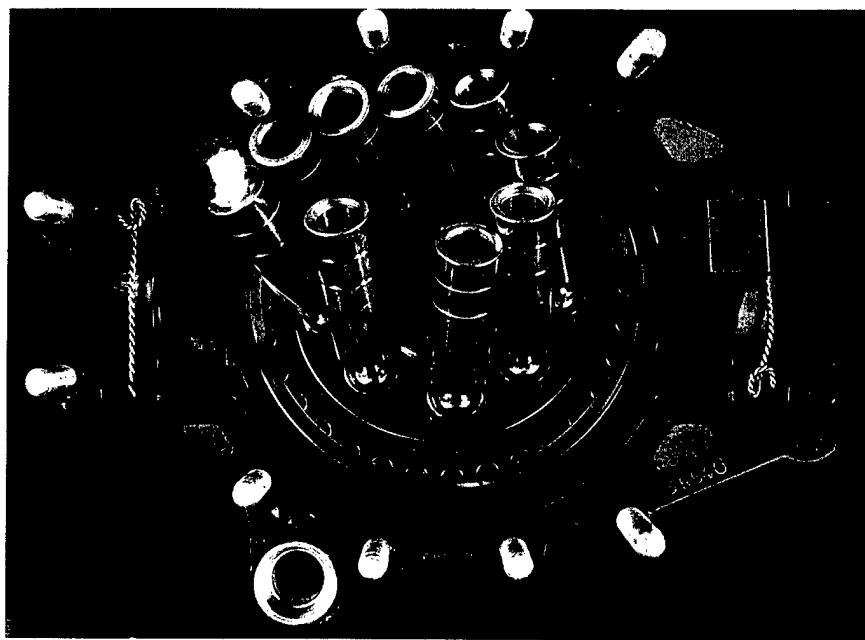
Barrel Bearing Race at 1343 Hours  
Pump Test 37 with MIL-PRF-83282

## APPENDIX B

Photos from Pump Test with Purified MIL-PRF-83282 (Test 38)

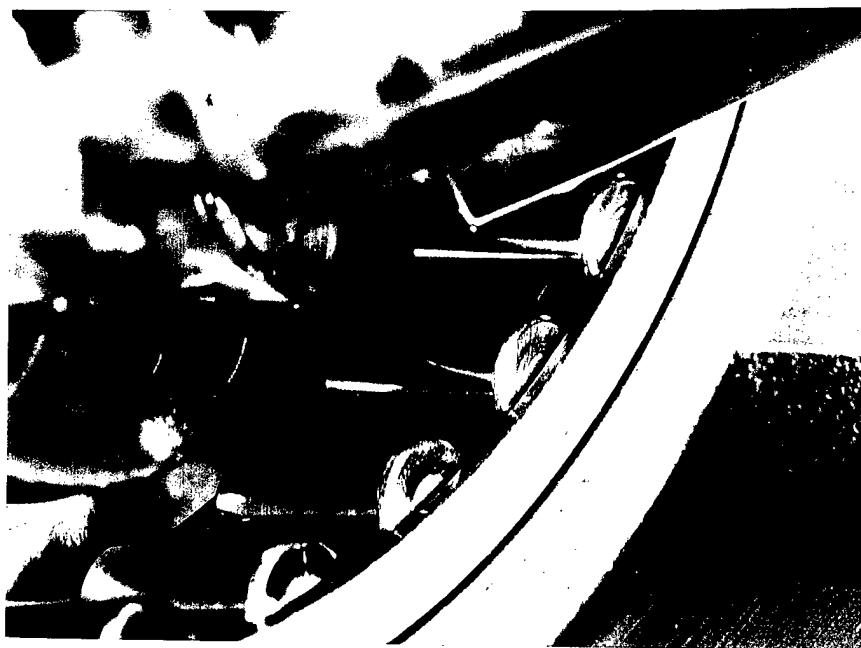


Cylinder Block Face

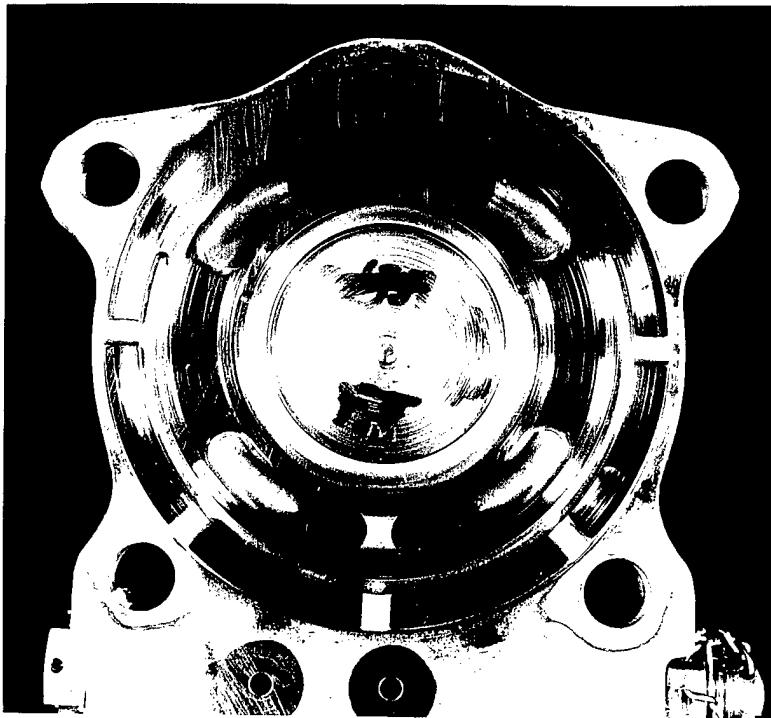


Partial Pump Assembly

Cylinder Block Face and Partial Pump Assembly at Pretest  
Pump Test 38 with Purified MIL-PRF-83282

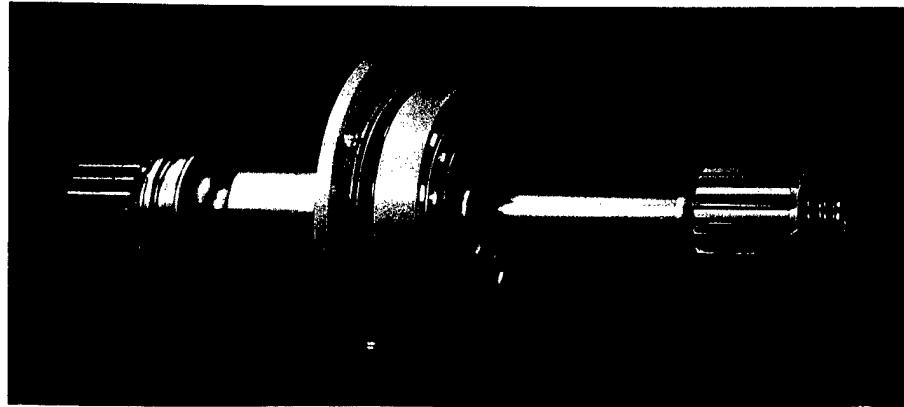


Barrel Roller Bearing

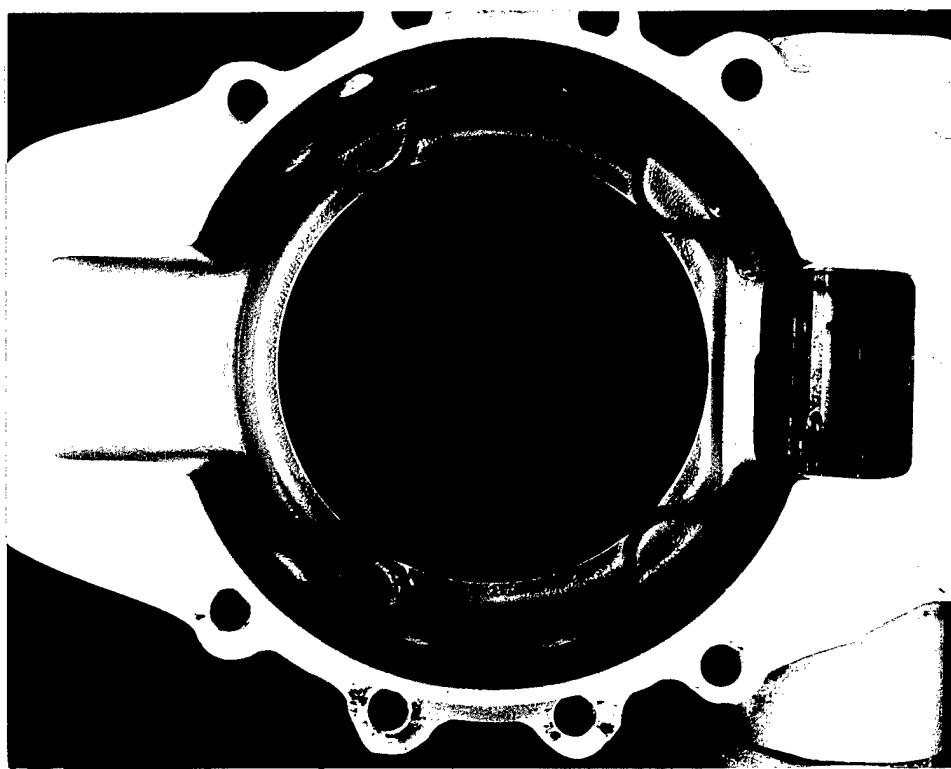


Valve Plate

Barrel Roller Bearing and Valve Plate at Pretest  
Pump Test 38 with Purified MIL-PRF-83282

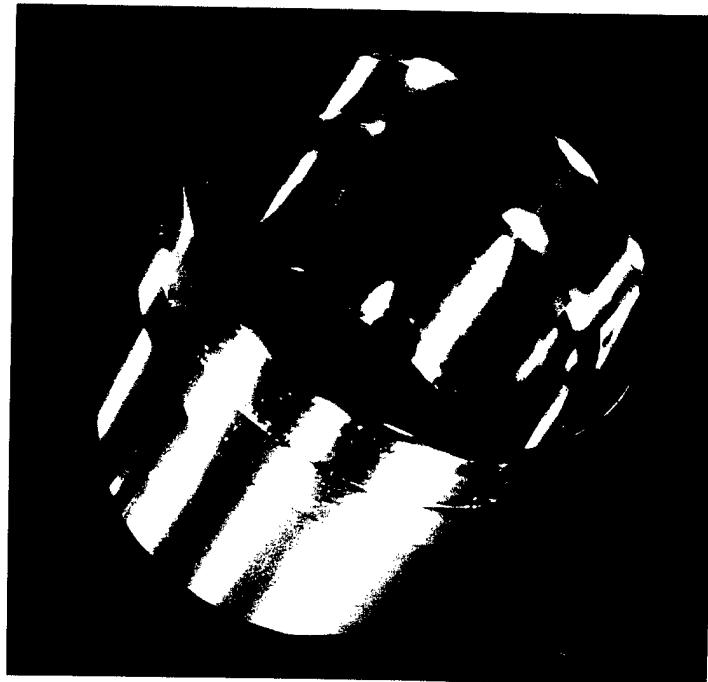


Internal Drive Shaft



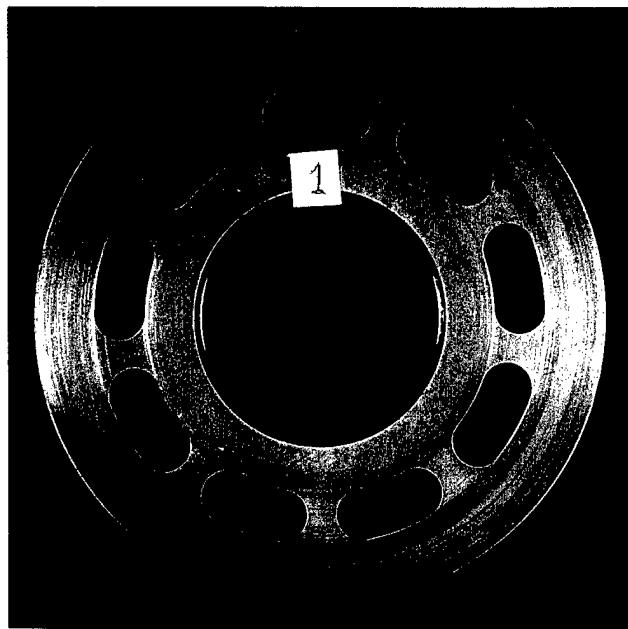
Housing

Internal Drive Shaft and Housing at Pretest  
Pump Test 38 with Purified MIL-PRF-83282



Barrel Bearing Race

Barrel Bearing Race at Pretest  
Pump Test 38 with Purified MIL-PRF-83282

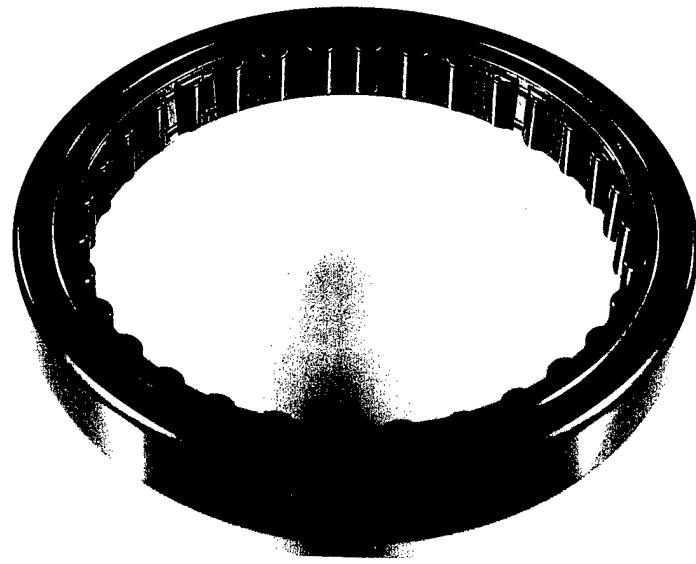


Cylinder Block Face

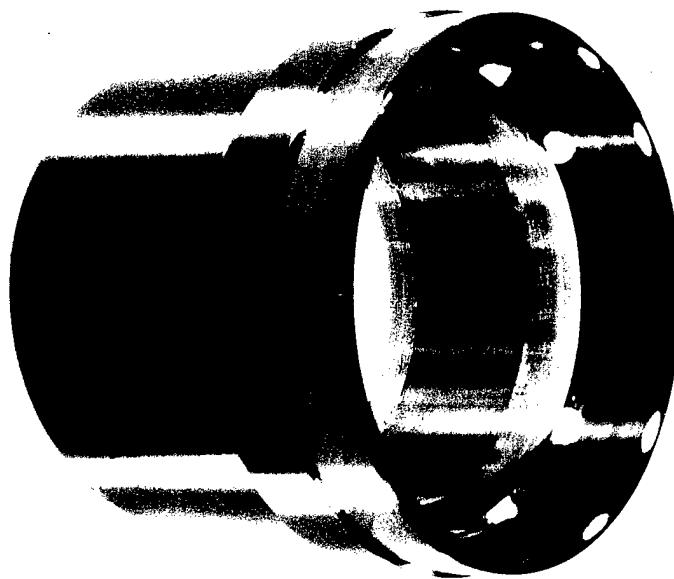


Enlargement of Cylinder Block Face

Cylinder Block Face at 954 Hours  
Pump Test 38 with Purified MIL-PRF-83282



Barrel Roller Bearing

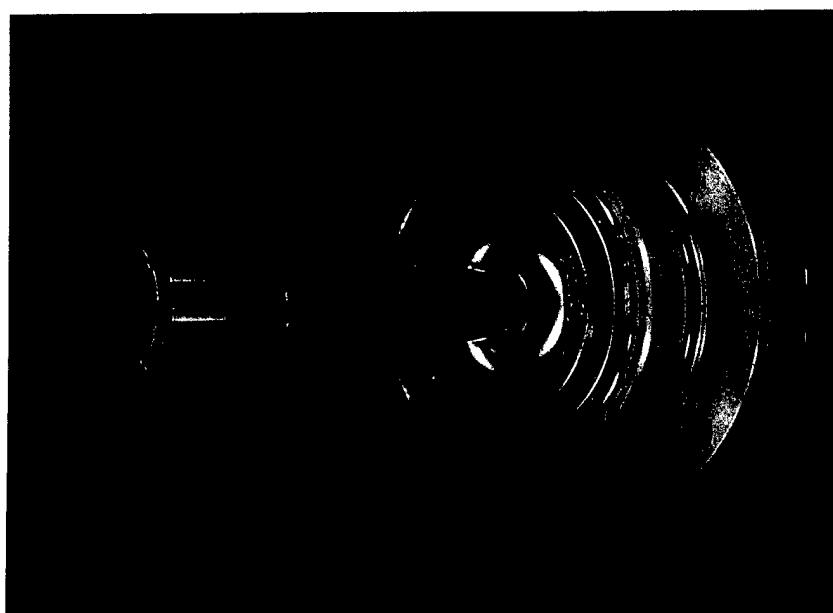


Barrel Bearing Race

Barrel Roller Bearing and Barrel Bearing Race at 954 Hours  
Pump Test 38 with Purified MIL-PRF-83282

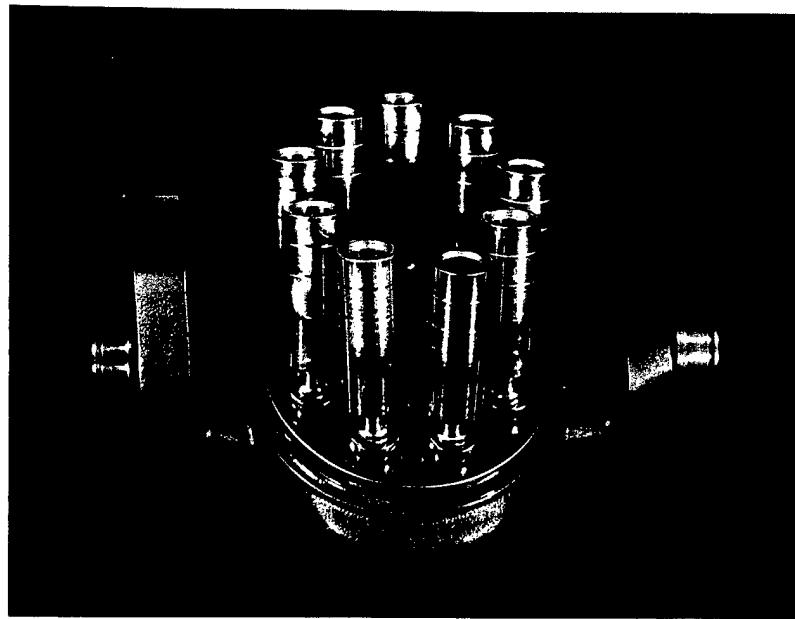


Internal Drive Shaft

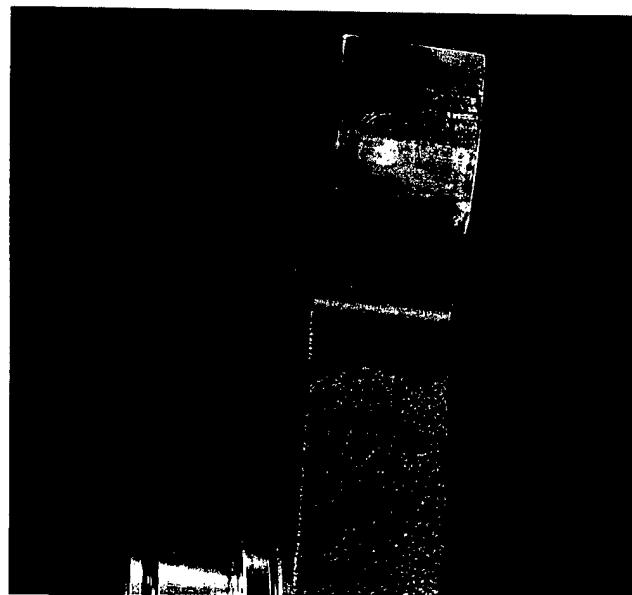


Enlargement of Internal Drive Shaft

Internal Drive Shaft at 954 Hours  
Pump Test 38 with Purified MIL-PRF-83282

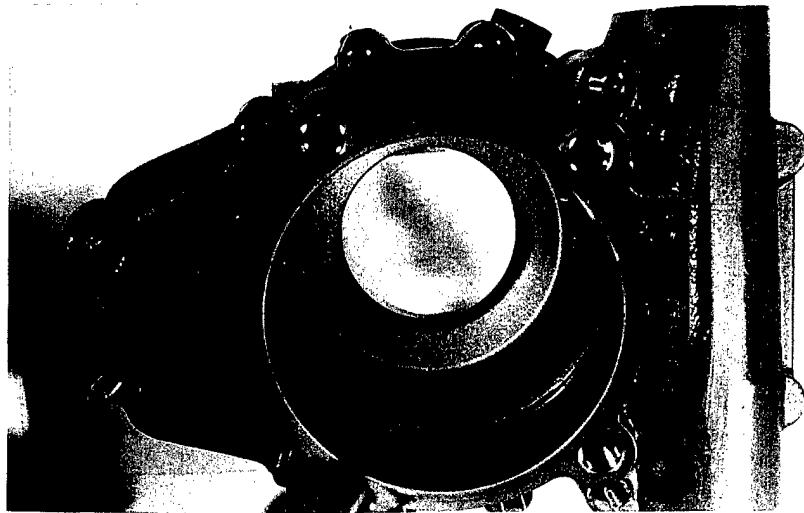


Piston and Hanger Subassembly

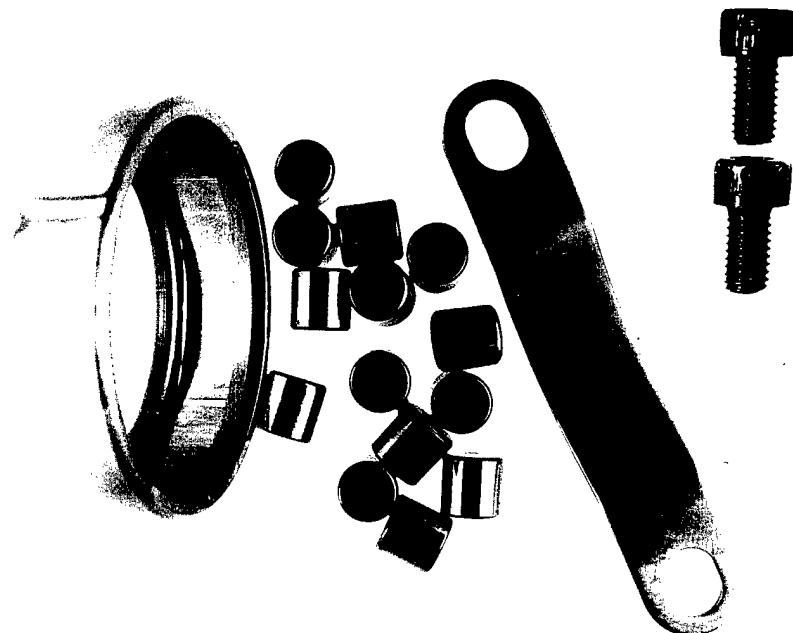


Hanger Arm

Piston and Hanger Subassembly at 954 Hours  
Pump Test 38 with Purified MIL-PRF-83282

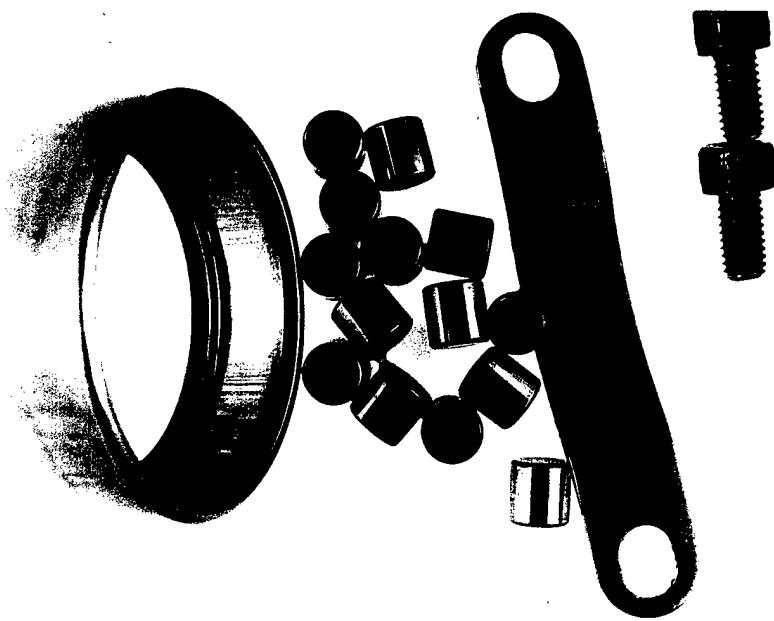


Housing

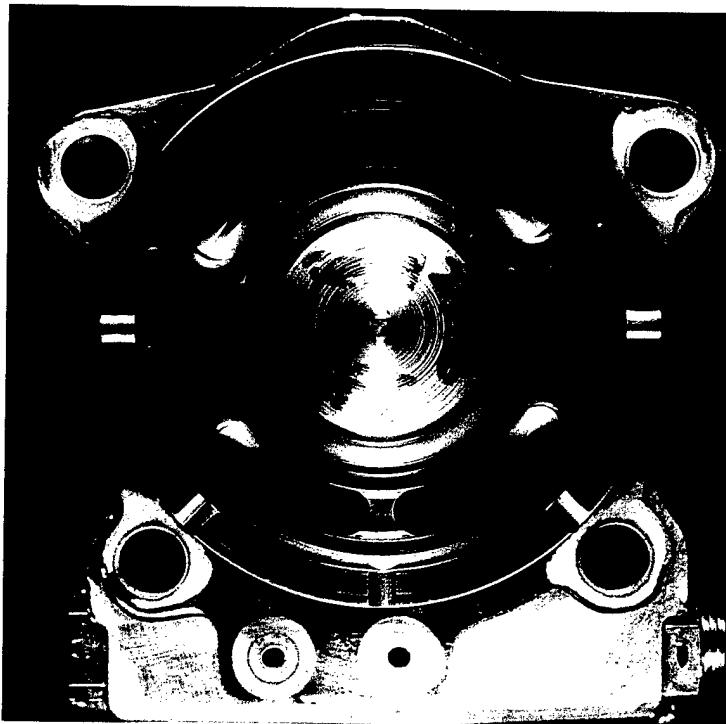


Hanger Bearing and Retainer, Arm-Side

Hanger Bearing and Retainer and Housing at 954 Hours  
Pump Test 38 with Purified MIL-PRF-83282

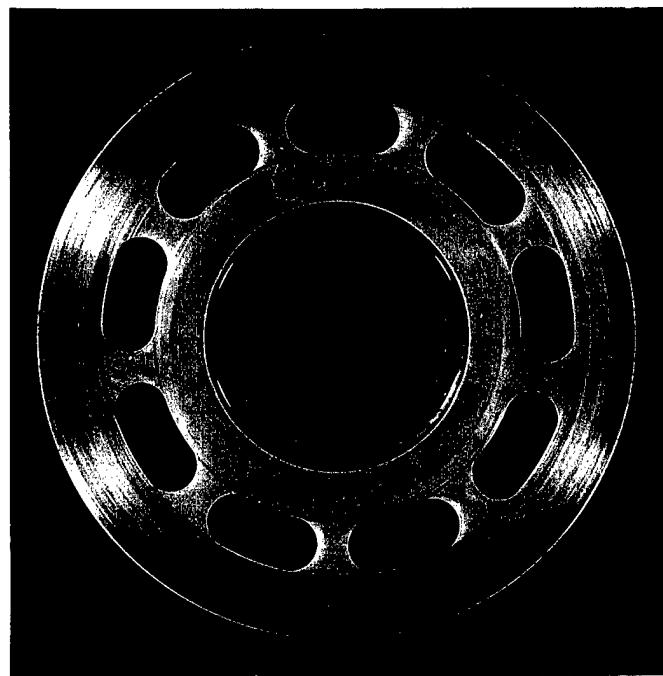


Hanger Bearing and Retainer, Non-Arm Side



Valve Plate

Hanger Bearing and Valve Plate at 954 Hours  
Pump Test 38 with Purified MIL-PRF-83282

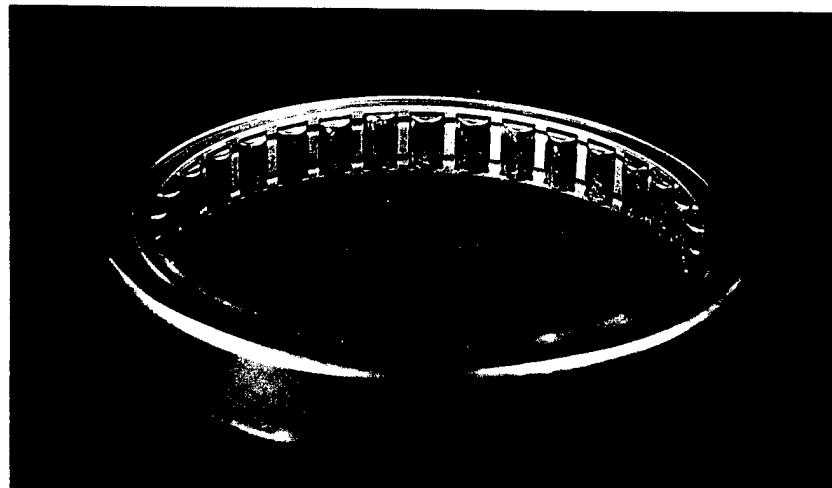


Cylinder Block Face

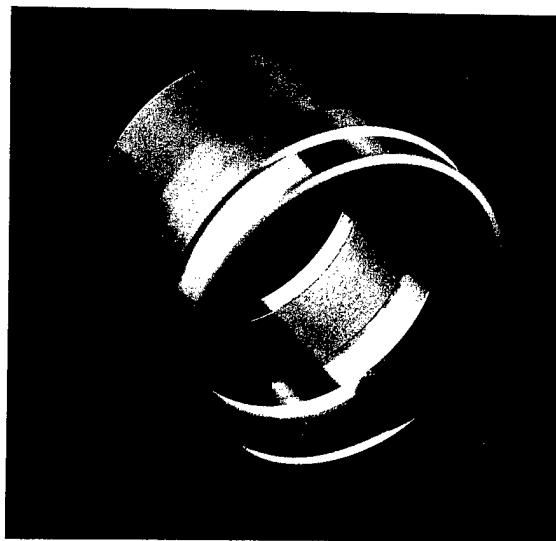


Piston and Hanger Subassembly

Cylinder Block Face and Piston and Hanger Subassembly at 1513 Hours  
Pump Test 38 with Purified MIL-PRF-83282

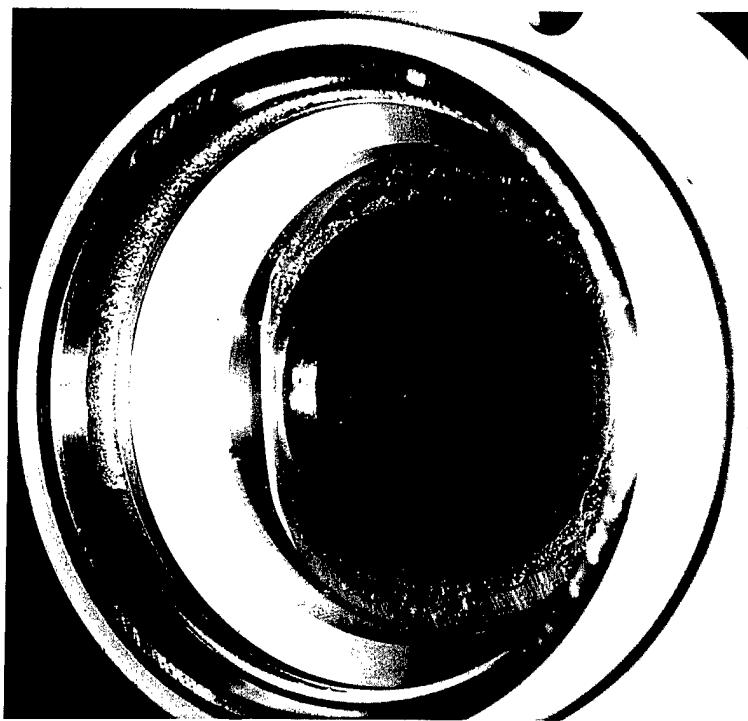


Barrel Roller Bearing

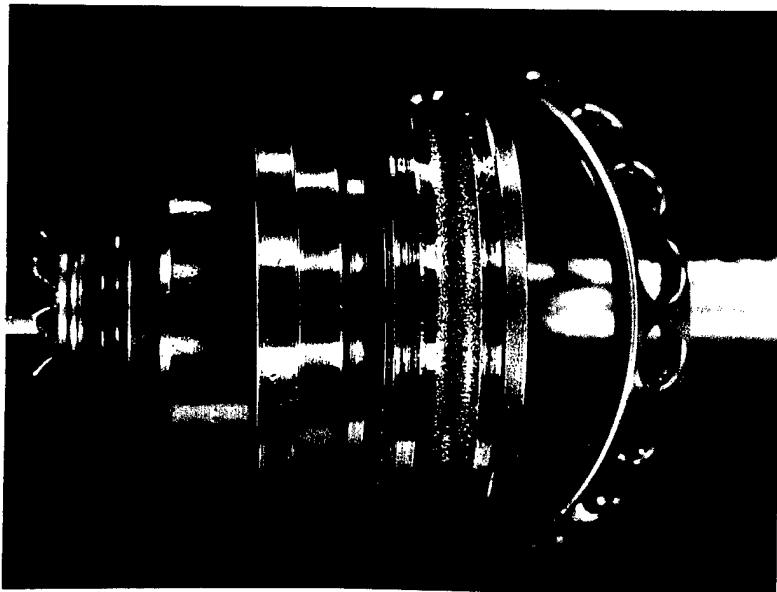


Barrel Bearing Race

Barrel Roller Bearing and Barrel Bearing Race at 1513 Hours  
Pump Test 38 with Purified MIL-PRF-83282

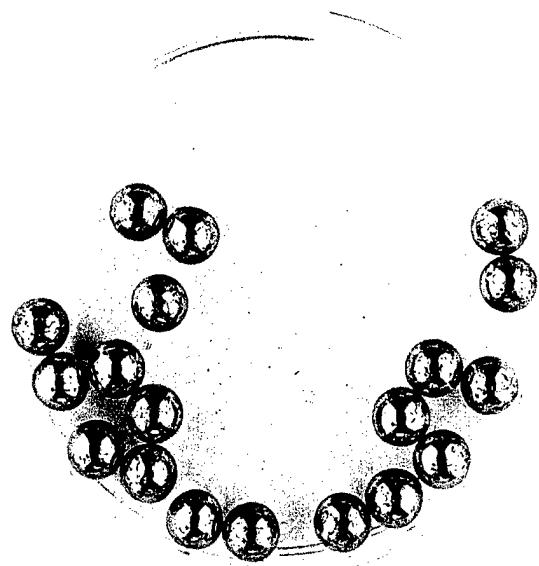


Bearing Outer Race in Housing

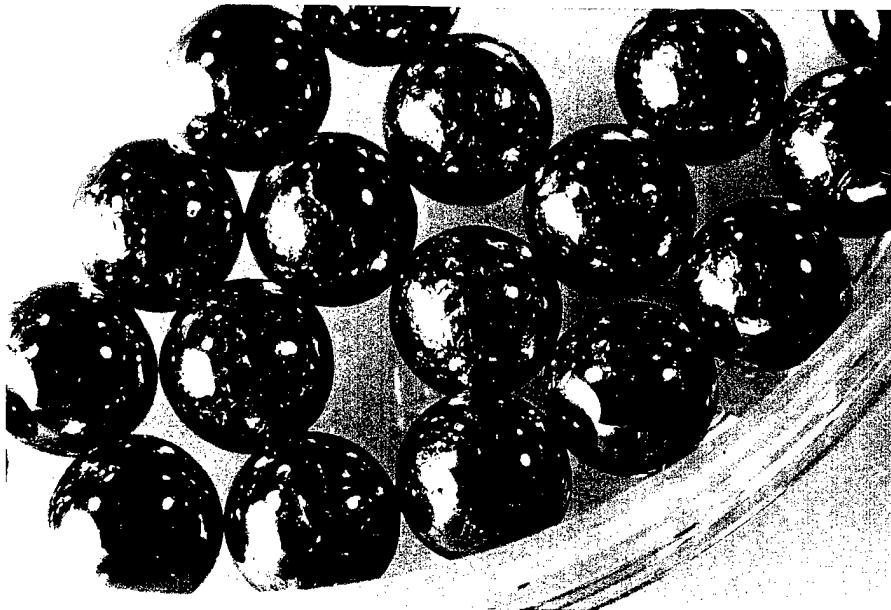


Ball Bearing

Bearing Retainer and Ball Bearing at 1513 Hours  
Pump Test 38 with Purified MIL-PRF-83282



Bearing Balls



Enlargement of Bearing Balls

Bearing Balls at 1513 Hours  
Pump Test 38 with Purified MIL-PRF-83282

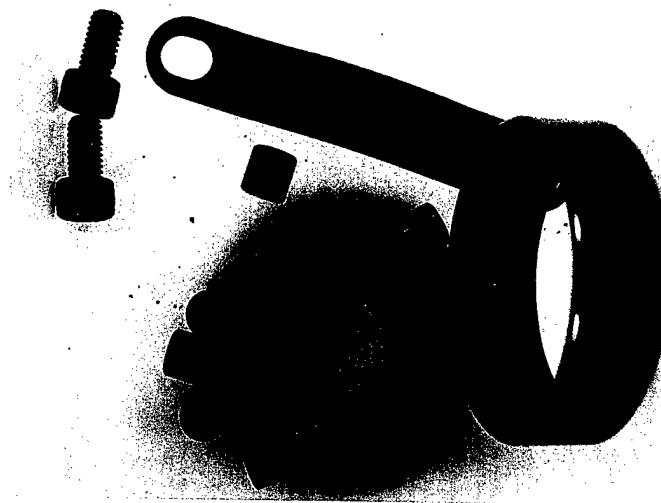


Hanger, Arm Side

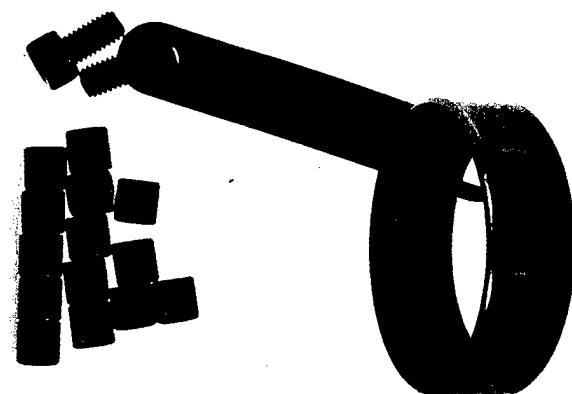


Hanger, Non-Arm Side

Hanger at 1513 Hours  
Pump Test 38 with Purified MIL-PRF-83282

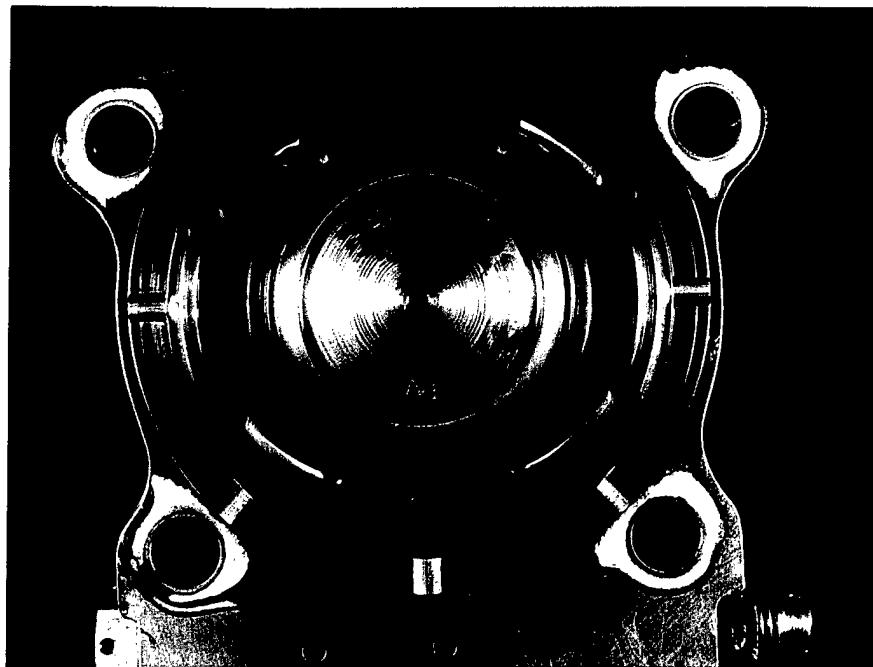


Hanger Bearing and Retainer, Arm Side

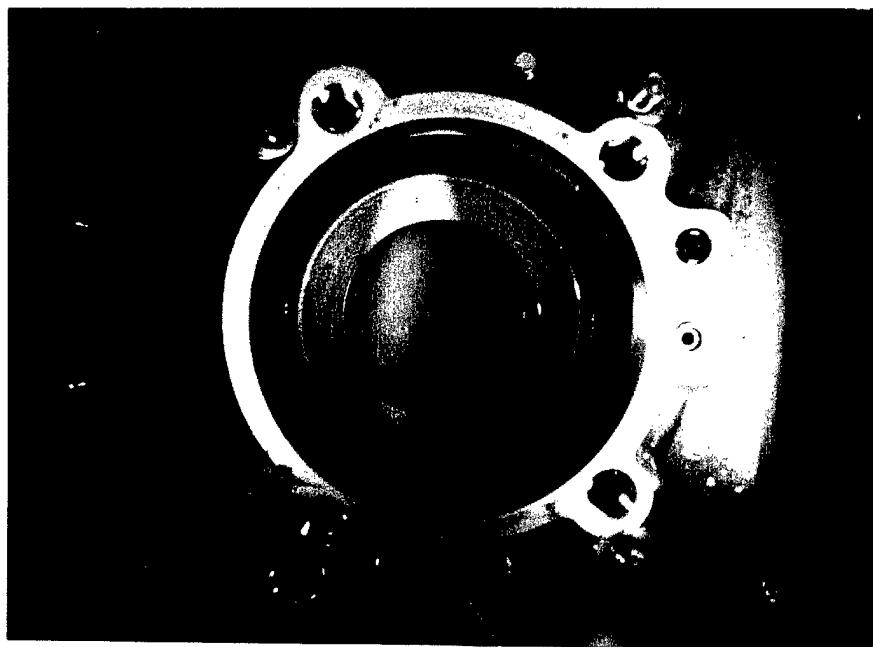


Hanger Bearing and Retainer, Non-Arm Side

Hanger Bearings and Retainers at 1513 Hours  
Pump Test 38 with Purified MIL-PRF-83282

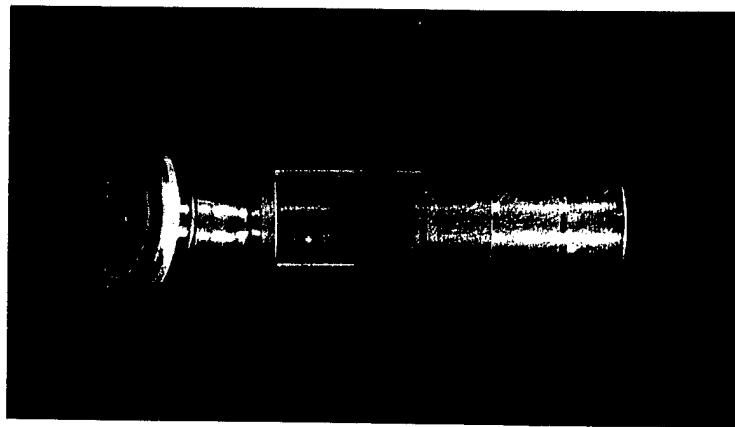


Valve Plate

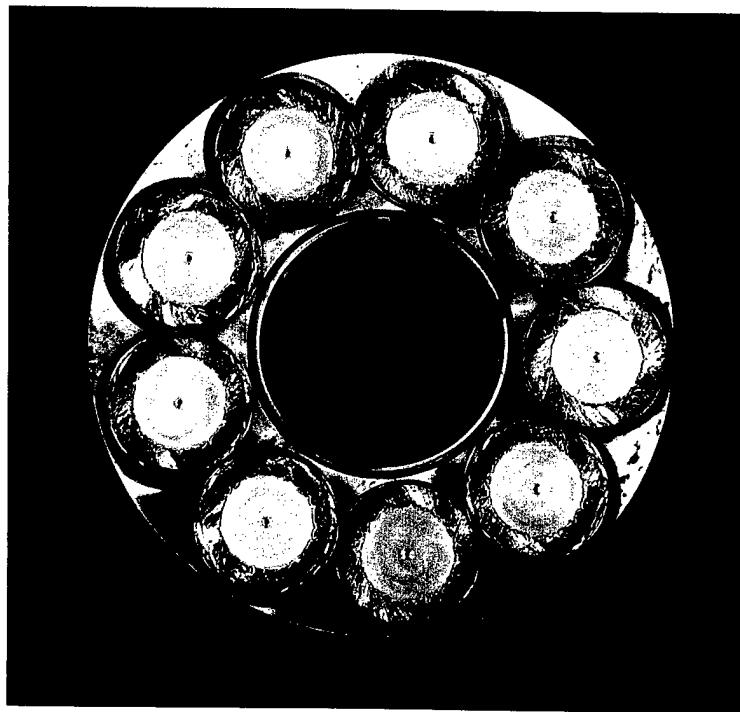


Housing

Valve Plate and Housing at 1513 Hours  
Pump Test 38 with Purified MIL-PRF-83282

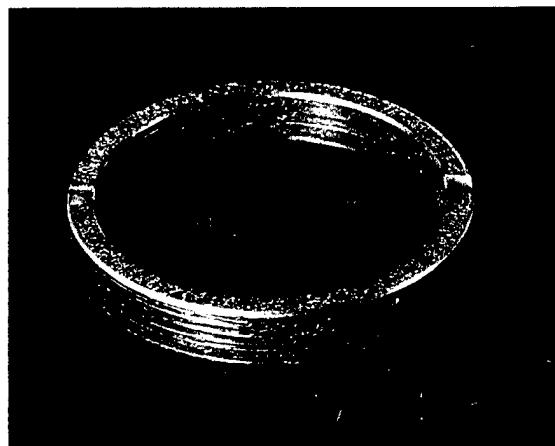


Actuator Piston

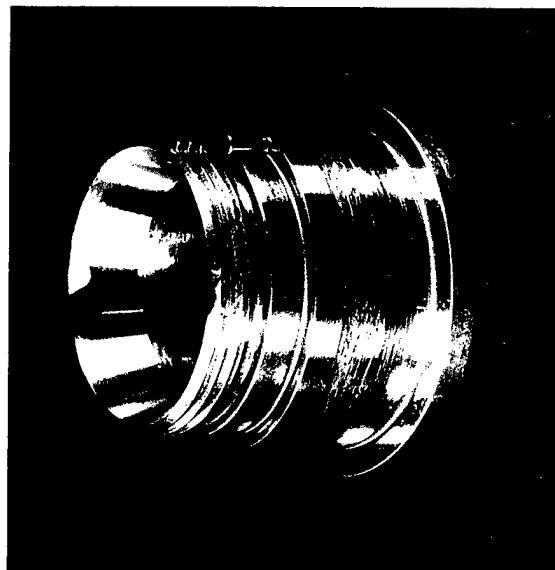


Piston Shoe Faces

Actuator Piston and Piston Shoe Faces at 1513 Hours  
Pump Test 38 with Purified MIL-PRF-83282

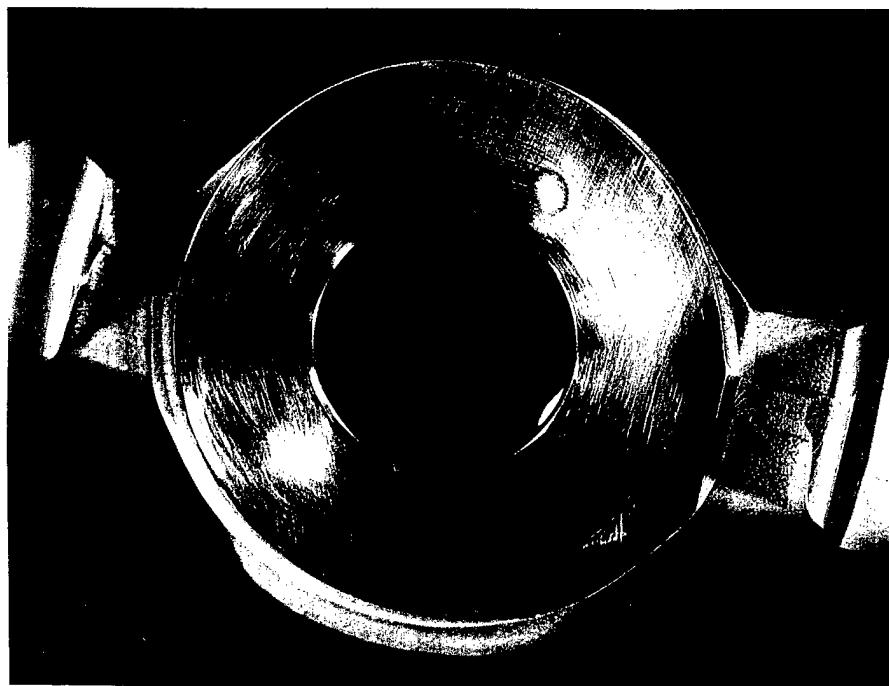


Thrust Washer



Bearing Retainer

Thrust Washer and Bearing Retainer at 1513 Hours  
Pump Test 38 with Purified MIL-PRF-83282



Hanger

Hanger at 1513 Hours  
Pump Test 38 with Purified MIL-PRF-83282

## **APPENDIX C**

**Raw Data for Pump Test 37  
with Fresh MIL-PRF-83282**

**Throttle Valve CLOSED**

Pump: ABEX Model AP12V-17, S/N MTE 1713

## Pump Test 37 - Throttle Valve Closed

Test Fluid: ML097-322 (ML-PRF-83282)

## Pump: ABEX Model AP12V-17, S/N MTE 1713

## Pump Test 37 - Throttle Valve Closed

## Test Fluid: ML097-322 (MIL-PRF-83282)

Date	Time	Test Hrs	Actual Test Hrs	Remarks	case drain	outlet T	throttle valve	pump outlet T	pump inlet P	main flow	case drain	motor speed	motor torque	main filter psd	case filter psd	delta P	gain	coolant heat
2/17/98	0:00		297.5		F	F			psig	psig	gal	gal	in-lb	in-lb	psi	psi	F	
2/17/98	0:14	286.3	297.7		251.8	245.4	230.6	227.4	87.9	3086	107.9	28.2	1.40	5020	127	7.6	17.4	88
2/17/98	8:37	294.2	306.1		251.4	244.6	229.8	226.2	86.2	3077	106.2	28.4	1.38	4981	146	8.0	18.2	87
2/17/98	16:53	302.1	314.4		250.4	242.8	229.6	225.6	85.0	3077	105.4	28.6	1.35	4984	132	6.3	17.4	87
2/17/98	23:11	308.0	320.7		250.4	243.1	228.6	225.4	84.1	3086	106.7	28.6	1.29	5037	156	7.6	16.6	85
2/18/98	0:00		321.5															
2/18/98	8:36	316.9	330.1		250.1	242.8	228.6	224.8	83.7	3077	104.2	28.3	1.27	4991	137	8.0	16.1	85
2/18/98	16:55	324.8	338.4		248.6	241.4	225.4	222.8	80.4	3069	99.7	28.5	1.19	4995	5078	6.7	16.6	83
2/18/98	23:14	330.8	344.7		248.4	241.7	226.8	223.6	80.4	3077	100.9	28.4	1.36	5009	4980	9.2	17.4	82
2/19/98	0:00		345.5															
2/19/98	8:39	339.7	354.1		248.6	241.4	227.1	223.3	80.8	3061	100.9	28.4	1.18	4995	5635	8.8	15.3	82
2/20/98	0:00		369.5															
2/21/98	0:00		393.5															
2/22/98	0:00		417.5															
2/22/98	0:32	400.0	418.0		251.7	244.9	230.4	226.9	87.5	3094	113.2	32.0	1.35	4981	5049	8.8	19.8	85
2/22/98	7:54	406.9	425.4		251.7	245.3	230.4	226.9	87.5	3077	107.5	28.3	1.36	5058	5117	7.6	17.8	87
2/22/98	16:18	414.8	433.8		251.3	244.4	229.7	226.1	86.2	3094	106.7	28.3	1.24	4974	4819	7.6	18.6	86
2/22/98	17:22	415.8	434.8		250.6	243.2	228.9	225.1	85.0	3102	105.8	28.6	1.31	4977	4722	8.4	17.4	86
2/22/98	23:36	421.8	441.1		251.1	243.9	229.1	225.8	84.6	3086	106.2	28.4	1.26	5034	5054	8.0	19.0	85
2/23/98	0:00		441.5															
2/23/98	7:58	429.7	449.4		249.1	242.3	227.4	222.2	82.5	3061	103.4	28.5	1.22	4988	4707	8.4	18.6	85
2/23/98	16:18	437.6	457.8		250.1	242.8	228.4	224.8	84.6	3077	104.6	28.3	1.37	4984	5210	7.6	17.0	87
2/23/98	23:39	444.5	465.1		249.4	242.2	227.4	224.1	82.5	3061	103.0	28.2	1.22	5020	5269	7.6	17.4	86
2/24/98	0:00		465.5															
2/24/98	8:03	452.4	473.5		249.3	241.7	227.3	224.1	82.5	3077	103.4	28.6	1.29	4974	5684	7.6	17.0	85
2/24/98	15:17	459.3	480.8		248.3	240.6	226.1	222.8	80.0	3077	107.1	31.9	1.23	5020	4756	9.6	18.6	83
2/25/98	0:00		489.5															
2/26/98	0:00		513.5															
2/27/98	0:00		537.5															
2/27/98	8:04	521.6	545.5		252.3	245.1	230.2	227.1	86.2	3069	106.2	28.3	1.41	5034	4971	8.0	18.2	86
2/27/98	16:15	530.4	553.7		250.6	243.8	229.6	225.8	82.9	3077	103.4	28.4	1.38	4984	5396	7.6	17.8	87

Pump: ABEX Model AP12V-17, S/N MTE 1713

## Pump Test 37 - Throttle Valve Closed

Test Fluid: ML-097-322 (ML-PRF-83282)

Pump: ABEX Model AP12V-17, S/N MTE 1713

## Pump Test 37 - Throttle Valve Closed

Test Fluid: MLO97-322 (MIL-PRF-83282)

Pump: ABEX Model AP12V-17; S/N MTE 1713

## Pump Test 37 - Throttle Valve Closed

Test Fluid: MIL-097-322 (MIL-PRF-83382)

Pump Test 37 - Throttle Valve Closed												Test Fluid: ML097-322 (MIL-PRF-83282)											
Date	Time	Test Hrs.	Actual Test Hrs.	Remarks	Case drain T	Throttle valve T	Pump outlet T	Pump inlet T	Throttle valve P	Case drain P	Motor torque	Main filter	Defeat P	Defeat filter	Heat gain	F							
4/22/98	12:54	963.5	1003.6		246.7	239.9	225.6	221.8	78.8	3045	97.3	28.2	1.42	4991	1494	8.0	17.8						
4/22/98	13:05		1003.8	Stopped																			
4/23/98	15:00		1003.8	Started																			
4/23/98	15:32				1004.3	1004.3	1004.3	1004.3	1004.3	3061	97.3	27.9	1.37	4974	1484	6.3	18.2						
4/27/98	10:46				1004.3	1004.3	1004.3	1004.3	1004.3	3061	97.3	27.9	1.37	4974	1484	6.3	18.2						
4/27/98	10:52				1004.4	1004.4	1004.4	1004.4	1004.4	3061	97.3	27.9	1.37	4974	1484	6.3	18.2						
4/29/98	8:31				1004.4	1004.4	1004.4	1004.4	1004.4	3061	97.3	27.9	1.37	4974	1484	6.3	18.2						
4/29/98	10:40		966.8	1006.6	248.4	241.7	227.3	224.1	80.8	3077	99.3	27.9	1.50	5009	1479	5.9	19.0						
4/29/98	14:46		971.2	1010.7	247.9	243.2	227.6	224.6	83.3	3061	102.2	27.7	1.50	5009	1479	5.9	19.0						
4/29/98	15:40		1011.6	Stopped																			
4/29/98	15:42		1011.6	Started																			
4/29/98	23:59		980.9	1019.9	246.7	241.2	226.3	222.7	81.2	3077	100.9	28.0	1.47	5041	1489	7.6	19.0						
4/30/98	0:00				1020.0																		
4/30/98	8:20	989.7	1028.3		249.4	243.1	228.2	225.4	83.7	3077	103.4	27.9	1.46	5023	1489	7.6	18.6						
4/30/98	16:31	998.4	1036.5		246.4	241.3	226.4	223.2	78.3	3061	98.9	27.7	1.44	4963	1484	8.0	18.6						
4/30/98	23:37	1006.1	1043.6		247.1	241.9	226.9	223.6	79.2	3061	99.7	27.9	1.41	4974	1484	8.0	18.6						
5/1/98	0:00		1044.0																				
5/1/98	8:58	1016.0	1053.0		247.2	241.9	226.4	223.8	79.2	3053	100.9	27.7	1.38	4974	1484	8.8	18.6						
5/1/98	11:01	1018.2	1055.0		246.9	241.4	226.9	222.9	79.2	3086	99.3	28.1	1.54	5012	1484	9.2	18.2						
5/1/98	11:44		1055.6	Stopped																			
5/1/98	15:31		1055.6	Started																			
5/1/98	18:07	1021.8	1058.2		246.9	241.7	226.9	223.7	79.6	3069	99.7	28.1	1.39	4984	1484	8.0	18.6						
5/1/98	23:22	1026.7	1063.4		247.2	241.8	227.2	223.8	81.7	3069	102.6	27.9	1.44	5009	1494	10.0	19.5						
5/2/98	0:00		1064.2																				
5/2/98	8:49	1034.6	1073.0		246.1	239.9	225.6	222.3	80.8	3061	102.2	27.8	1.40	4981	1484	8.0	17.8						
5/2/98	16:11	1040.7	1080.4		247.1	241.6	227.1	223.8	80.4	3053	100.1	27.8	1.44	4991	1484	10.0	18.6						
5/2/98	23:32	1046.9	1087.7		246.6	241.4	226.6	223.3	80.4	3077	100.9	28.1	1.49	4995	1484	7.6	19.5						
5/3/98	0:00		1088.2																				
5/3/98	8:59	1054.8	1097.2		247.1	241.9	227.2	224.4	80.0	3061	100.9	27.9	1.44	5027	1484	5.9	19.5						
5/3/98	16:21	1061.0	1104.6		247.1	241.9	227.1	223.6	80.0	3061	100.1	27.9	1.49	4974	1479	8.8	19.5						
5/3/98	23:42	1067.1	1111.9		247.1	241.1	226.7	223.8	80.4	3077	100.1	27.7	1.45	4998	1475	10.0	19.0						

## Pump Test 37 - Throttle Valve Closed

Printed: ABEX Model AP12V-17, S/N MTE 1713

Test Fluid: M1097-322 (M1L-PRF-83282)

Pump: ABEX Model AP12V-17, S/N MTE 1713

## Pump Test 37 - Throttle Valve Closed

Test Fluid: MLO97-322 (MIL-PRF-833282)

## APPENDIX D

Raw Data for Pump Test 37  
with Fresh MIL-PRF-83282

Throttle Valve OPEN

Pump Test 37 - Throttle Valve Opened												Test Fluid: MLO97-322 (MIL-PRF-83282)												
Date	Time	Test Hrs.	Actual Test Hrs.	Remarks	Cassette drain outlet T	Throttle valve	Cassette drain outlet T	Pump inlet T	Pump outlet T	Pump inlet P	Pump outlet P	Throttle valve	Cassette drain outlet T	Main flow	Cassette drain	Main filter in-lbf	Main filter psd	Main filter F	Case filter in-lbf	Case filter psd	Case filter F	Coolant heat gain		
12/20/97	0.0	0.0	Start																					
1/15/98	1:21	66.9	67.0	Stopped																				
1/15/98	1:30		Start																					
1/16/98	9:09		98.7	Stopped																				
2/6/98	11:25		98.7	Start																				
2/6/98	12:04	83.7	99.4					238.4	229.6	215.4	210.6	92.4	3086	125.4	35.7	1.06	4977	176	10.8	14.0	55			
2/6/98	17:06	88.6	104.4					250.2	242.6	228.1	223.7	84.6	3069	115.6	35.9	1.42	5030	107	11.2	17.8	81			
2/7/98	0:00		111.3																					
2/8/98	0:00		135.3																					
2/9/98	0:00		159.3																					
2/9/98	9:44	149.9	169.0					245.3	238.2	223.3	219.7	83.3	3069	114.0	34.7	1.23	5034	166	8.8	16.1	79			
2/9/98	19:07	158.8	178.4					246.9	236.9	224.6	217.6	86.6	3069	119.3	35.5	1.23	4988	146	10.4	16.5	81			
2/9/98	23:20	162.8	182.6					246.7	239.6	224.7	221.1	85.4	3069	118.1	35.5	1.36	5058	117	9.6	16.1	82			
2/10/98	0:00		183.3																					
2/10/98	0:23	163.8	183.7					247.1	240.3	225.1	222.2	87.5	3086	119.3	35.7	1.21	5030	166	9.6	17.0	82			
2/10/98	3:32	166.8	186.8					247.6	240.8	225.9	222.2	87.0	3069	119.3	35.8	1.21	4988	176	9.2	17.8	83			
2/10/98	3:57	167.1	187.2	Stopped																				
2/12/98	9:43	182.4	187.2	Started																				
2/13/98	0:00		201.5																					
2/14/98	0:00		225.5																					
2/14/98	5:05	223.0	230.6					246.8	240.4	224.4	221.9	79.2	3061	109.9	35.1	1.26	5002	161	10.0	17.8	84			
2/14/98	15:36	232.8	241.1					247.2	240.3	225.6	222.2	89.1	3069	121.0	35.9	1.37	5027	132	10.4	18.2	82			
2/14/98	23:58	240.8	249.5					249.3	241.1	227.3	224.4	89.5	3069	120.5	35.6	1.41	4984	161	10.8	18.6	83			
2/15/98	0:00		249.5																					
2/15/98	1:01	241.7	250.5					248.4	241.7	226.8	223.6	88.3	3069	121.0	35.6	1.31	4984	156	10.4	18.6	83			
2/15/98	10:29	250.7	260.0					250.2	242.9	228.6	225.3	89.5	3061	120.5	35.9	1.35	4981	176	11.6	19.4	85			
2/15/98	20:59	260.5	270.5					249.7	243.3	228.6	224.8	89.1	3086	120.5	36.0	1.40	5023	156	10.4	18.6	83			

## Pump Test 37 - Throttle Valve Opened

Pump: ABEX Model AP12V-17: S/N MTE 1713

Test Fluid: ML097-322 (MIL-PRF-833282)

## Pump Test 37 - Throttle Valve Opened

Phm8: ABEX Model AP12V-17. S/N MTE 1713

Test Eluid: MI 097-322 (MII) -PBE-83282)

## Pump Test 37 - Throttle Valve Opened

Pump: ABEX Model AP12V-17, S/N MTE 1713

Test Fluid: MLO97-322 (MIL-PRF-83282)

Date	Time	Test Hrs.	Actual Test	Remarks	case T	outlet T	throttle valve	pump outlet T	pump inlet T	throttle valve	case drain	main flow	motor speed	motor torque	main filter	case filter	delta P filter	coolant heat gain
3/7/98	7:57	723.6	737.3		F	F	F	F	F	psig	psig	psig	psig	psig	psig	psig	psig	F
3/7/98	16:21	732.4	745.6		249.4	243.1	228.6	224.9	224.9	3086	114.4	35.9	1.40	5051	4932	11.6	21.1	86
3/7/98	23:42	740.1	753.0		249.3	242.8	228.2	224.3	224.3	3069	113.6	35.6	1.55	4995	5752	10.4	21.1	87
3/8/98	0:00				249.9	243.9	229.2	225.6	225.6	3086	115.2	35.5	1.50	5037	4492	10.4	22.3	88
3/8/98	8:07	748.9	761.4		753.3													
3/8/98	0:00				250.7	244.3	229.8	226.1	226.1	3069	115.2	35.5	1.47	4995	4727	10.4	22.3	89
3/9/98	0:00				777.3													
3/10/98	0:00				801.3													
3/11/98	0:00				825.3													
3/11/98	8:12	824.7	833.5		248.2	241.9	227.4	224.2	224.2	3086	115.6	35.2	1.41	5012	4878	10.8	20.3	86
3/11/98	16:26	833.5	841.7		246.9	241.3	226.6	223.2	223.2	3069	113.2	35.1	1.46	4998	5352	10.4	21.9	87
3/11/98	23:46	841.2	849.1		247.4	241.6	226.7	223.4	223.4	3061	114.0	35.2	1.47	4995	4995	10.8	21.9	87
3/12/98	0:00				849.3													
3/12/98	8:09	850.0	857.4		248.8	242.9	228.1	224.8	224.8	3094	115.6	35.4	1.47	5005	5679	11.6	22.7	88
3/12/98	16:27	858.8	865.8		248.2	242.7	227.9	224.6	224.6	3077	115.2	35.1	1.54	4995	5381	11.6	22.3	87
3/12/98	23:46	866.5	873.1		248.1	242.6	227.7	224.1	224.1	3086	116.1	35.5	1.42	4995	5107	12.5	20.7	88
3/13/98	0:00				873.3													
3/13/98	8:08	875.3	881.4		248.7	243.1	228.3	224.6	224.6	3086	113.6	35.2	1.46	5041	4663	10.0	21.9	90
3/13/98	13:18	880.8	886.6		250.3	244.8	229.9	226.3	226.3	3086	116.9	35.5	1.55	5037	5103	10.8	23.6	90
3/14/98	0:00				897.3													
3/15/98	0:00				921.3													
3/16/98	0:00				945.3													
3/16/98	8:11	951.1	953.5		245.4	239.4	224.6	221.8	221.8	3077	109.9	35.0	1.40	5030	4624	12.1	21.9	86
3/16/98	16:28	959.9	961.8		246.9	241.2	226.9	223.7	223.7	3077	112.4	35.0	1.46	4988	5273	10.8	21.9	87
3/16/98	23:47	967.6	969.1		246.8	241.7	227.4	223.6	223.6	3077	113.2	35.1	1.46	5030	4810	11.6	22.3	86
3/17/98	0:00				969.3													
3/17/98	8:10	976.4	977.5		248.1	243.3	228.4	224.8	224.8	3077	114.8	35.1	1.46	5055	4556	10.8	23.2	87
3/17/98	16:24	985.2	985.7		249.1	244.3	229.4	225.8	225.8	3077	117.3	35.2	1.59	4991	5098	11.2	23.1	87

Pump: ABEX Model AP12V-17, S/N MTE 1713

## Pump Test 37 - Throttle Valve Opened

Test Fluid: MLO97-322 (MIL-PBE-83282)

Pump: ABEX Model AP12V-17, S/N MTE 1713

## Pump Test 37 - Throttle Valve Opened

Test Eluid: ML097-322 (ML-PRF-83282)

Pump: ABEX Model APP12V-17, S/N MTE 1713

## Pump Test 37 - Throttle Valve Opened

Test Fluid: ML097-322 (ML-PRE-83282)

Pump: ABEX Model AP12V-17, S/N MTE 1713

## Pump Test 37 - Throttle Valve Opened

Test Fluid: MI-Q97-322 (MII-PRF-83282)

**APPENDIX E**

**Raw Data for Pump Test 38  
with Purified MIL-PRF-83282**

**Throttle Valve CLOSED**

Pump Test 38 - Throttle Valve Closed

Pump: ABEX Model AP12V-17, S/N MTE 1348

Test Fluid: MLO97-322 (MIL-PRF-83282)

Date	Time	Test Hrs.	Actual Test	Test Hrs.	Remarks	Cassie drain out	Throttle valve outlet T	Pump outlet T	Pump inlet T	Pump outlet P	Throttle valve outlet P	Main flow gal	Cassie drain gal	Motor speed rpm	Motor torque in-lbf	Main filter psi	Cassie filter psi	Main filter psi	Cassie filter psi
8/11/98	13:15	0.0	Started																
8/11/98	16:10	3.0	2.9	246.3	239.1	224.2	220.6	88.2	3085.1	108.2	28.1	1.11	4977	673.8	2.5	10.5			
8/11/98	21:22	8.0	8.1	248.2	240.7	225.8	222.6	92.8	3101.5	114.3	28.0	1.06	5016	669.0	3.7	10.9			
8/12/98	0.00		10.8																
8/12/98	0:31	11.0	11.3	248.3	240.4	226.1	221.8	92.0	3093.3	110.2	27.7	1.10	5020	673.8	2.5	10.9			
8/12/98	5:46	16.0	16.5	248.3	241.1	226.3	222.2	90.3	3093.3	112.3	27.6	1.16	5009	669.0	3.7	10.5			
8/12/98	14:05	24.0	24.8	248.1	240.4	225.6	221.9	89.5	3085.1	110.2	28.0	1.06	4995	669.0	5.0	9.7			
8/12/98	16:06	26.0	26.9	248.8	241.7	226.4	223.2	91.5	3068.8	111.9	28.0	1.09	5041	669.0	2.1	10.1			
8/12/98	22:25	32.0	33.2	248.4	241.2	226.4	223.1	89.9	3076.9	110.7	27.8	1.15	5041	673.8	2.5	10.9			
8/13/98	0:00		34.8																
8/13/98	6:49	40.1	41.6	248.3	241.1	226.3	222.6	88.2	3093.3	109.0	27.8	1.15	5073	669.0	3.7	10.5			
8/13/98	15:09	48.1	49.9	248.6	241.4	226.6	222.9	89.5	3052.4	109.4	27.7	1.22	4991	669.0	5.0	10.5			
8/13/98	23:31	56.1	58.3	248.6	241.3	226.6	222.8	85.7	3093.3	106.6	27.6	1.13	4988	669.0	2.9	10.6			
8/14/98	0:00		58.8																
8/14/98	7:56	64.1	66.7	248.3	240.7	225.9	222.7	84.1	3076.9	104.9	27.7	1.20	5005	669.0	2.9	10.6			
8/14/98	15:00		73.8	Stopped															
8/17/98	9:44		73.8	Started															
8/17/98	12:38	73.7	76.7	248.8	240.4	226.4	222.6	87.8	3076.9	109.0	27.9	1.05	5002	678.7	4.5	10.1			
8/17/98	19:58	80.6	84.0	248.3	240.7	225.8	222.2	87.8	3093.3	108.2	27.7	1.06	5009	678.7	5.0	10.5			
8/18/98	4:22	88.5	92.4	248.9	241.1	226.6	222.4	86.6	3060.6	108.2	27.9	1.12	5012	678.7	4.1	12.2			
8/18/98	12:42	96.4	100.8	249.4	241.4	226.7	222.9	88.6	3068.8	109.0	27.7	1.04	5005	678.7	3.7	10.5			
8/18/98	21:03	104.3	109.1	248.7	241.2	226.3	222.7	90.7	3076.9	112.3	27.8	1.09	5066	683.6	2.5	10.9			
8/19/98	0:00		112.1																
8/19/98	5:27	112.2	117.5	248.2	240.7	225.8	222.2	88.6	3101.5	107.4	28.2	1.21	4998	678.7	2.9	12.2			
8/19/98	14:46	121.1	126.8	248.6	241.4	226.2	221.3	89.5	3076.9	110.2	27.9	1.13	5012	683.6	4.1	11.4			
8/19/98	23:09	129.0	135.2	249.2	241.2	226.3	222.7	89.1	3085.1	109.0	27.8	1.06	5030	683.6	3.7	11.0			
8/20/98	0:00		136.1																
8/20/98	7:32	136.9	143.6	248.9	241.2	226.1	222.1	88.2	3076.9	107.4	28.1	1.23	5027	678.7	5.0	11.8			
8/20/98	16:52	145.8	152.9	249.6	241.6	227.1	223.1	89.9	3093.3	109.4	27.6	1.22	5027	678.7	3.7	11.8			
8/21/98	1:15	153.8	161.3	249.1	241.2	226.3	222.7	88.6	3101.5	108.6	27.8	1.20	5002	678.7	3.7	11.8			

Pump: ABEX Model AP12V-17, S/N MTE 1348

## Pump Test 38 - Throttle Valve Closed

Test Fluid: ML097-322 (ML-PRF-83282)

## Pump Test 38 - Throttle Valve Closed

Pump: ABEX Model AP12V-17, SIN MTE 1348

Test Fluid: MLO97-322 (MIL-PRF-83282)

Date	Time	Actual Hrs.	Test Hrs.	Remarks	T	case drain out	throttle valve	outlet T	pump outlet T	pump inlet T	pump outlet P	pump inlet P	outlet P	throttle valve	main flow	case drain	motor speed	motor torque	main filter	case filter	delta P	psi		
11/14/98	18:19			Started																				
11/14/98	20:32			Stopped																				
11/17/98	12:03			Started																				
11/17/98	14:20	309.9	318.3		247.4	236.0	226.2	221.5	87.0	3068.8	106.2	28.8	121	4988	703.1	0.5	13.4							
11/17/98	22:37	317.8	326.6		246.8	239.2	225.2	220.7	86.2	3060.6	105.3	28.2	126	5037	683.6	0.1	13.0							
11/18/98	0:00			327.9																				
11/18/98	7:01	325.7	335.0		246.7	239.2	225.5	220.7	86.2	3093.3	104.1	27.6	129	5005	669.0	2.1	12.2							
11/18/98	15:07	333.7	343.1		247.2	239.4	225.7	221.0	87.8	3085.1	100.8	28.5	129	5034	688.5	2.1	11.8							
11/18/98	23:26	341.6	351.4		246.9	239.4	225.3	221.3	88.2	3085.1	105.3	28.1	116	4988	683.6	4.5	12.6							
11/19/98	0:00			351.9																				
11/19/98	7:49	349.5	359.8		246.8	239.0	225.2	220.5	87.4	3076.9	107.4	27.6	120	5037	673.8	-1.6	13.0							
11/19/98	15:57	357.4	367.9		247.0	239.4	225.8	220.5	88.2	3085.1	105.3	27.4	123	4984	664.1	3.3	13.0							
11/20/98	0:17	365.3	376.2		246.9	239.3	225.8	221.2	88.2	3068.8	110.7	27.7	123	5027	678.7	7.4	13.8							
11/20/98	8:40	373.2	384.6		246.9	239.8	225.8	219.3	89.1	3085.1	108.6	27.4	124	5023	669.0	4.1	13.4							
11/20/98	16:53	381.1	392.8		246.4	238.9	224.9	220.4	88.6	3068.8	108.2	27.4	124	5012	669.0	2.9	13.0							
11/21/98	0:00			399.9																				
11/21/98	0:14	388.0	400.19		246.4	238.8	225.2	220.3	89.1	3085.1	110.2	27.6	114	4991	669.0	2.5	12.2							
11/21/98	0:48			400.7	Stopped																			
11/25/98	9:17	400.7	Started																					
11/25/98	11:18	391.5	402.7		245.9	238.4	224.4	219.9	87.4	3060.6	107.4	28.4	131	4984	693.4	4.5	12.6							
11/25/98	19:29	399.4	410.9		245.9	238.2	224.4	220.0	88.6	3085.1	109.0	28.1	132	5023	678.7	3.7	13.0							
11/26/98	0:00			415.7																				
11/26/98	4:56	408.3	420.6		245.4	238.3	224.7	219.8	87.0	3085.1	107.0	27.3	123	5012	664.1	5.0	13.8							
11/26/98	13:20	416.2	429.0		245.2	237.3	224.0	219.5	86.2	3076.9	104.9	26.7	122	4995	644.5	2.5	13.4							
11/26/98	21:44	424.2	437.4		244.5	237.4	223.4	218.9	86.2	3076.9	104.9	25.5	126	5044	620.1	1.7	13.0							
11/27/98	0:00			439.7																				
11/27/98	6:08	432.1	445.9		241.9	234.3	220.3	216.2	84.1	3085.1	100.8	24.7	116	4977	605.5	2.9	13.4							
11/27/98	14:33	440.0	454.3		240.9	233.0	219.3	215.0	83.7	3076.9	100.8	24.7	126	4981	600.6	4.1	13.9							
11/27/98	22:57	447.9	462.7		240.2	232.2	218.4	214.4	83.7	3076.9	101.3	24.5	124	5020	590.8	2.9	13.4							
11/28/98	8:24	456.8	472.1		238.5	230.0	216.4	212.3	82.4	3076.9	98.8	24.1	119	5009	581.1	2.5	12.6							

Pump Test 38 - Throttle Valve Closed

Pump: ABEX Model AP12V-17, S/N MTE 1348

Test Fluid: MLO97-322 (MIL-PRF-83282)

Date	Test Hrs.	Actual Test Hrs.	Remarks	Case drain out	Throttle valve	Pump outlet T	Pump inlet T	Pump outlet P	Pump inlet P	Throttle valve	Main flow	Case drain	Motor speed rpm	Motor torque in-lbf	Main filter psi	Casing filter psi	Casing filter psi
11/28/98	16:48	464.7	480.5	F	F	F	F	psig	psig	99.2	23.7	1.22	4998	576.2	5.0	12.2	
11/29/98	0:00	487.7															
11/29/98	1:08	472.6	488.9	237.4	231.4	213.7	213.7	88.6	3085.1	105.3	23.7	1.27	5062	576.2	4.5	13.4	
11/29/98	9:33	480.5	497.3	239.3	231.2	217.5	213.0	88.2	3076.9	103.3	23.4	1.22	5058	571.3	2.1	13.4	
11/29/98	17:57	488.4	505.7	238.8	231.2	217.4	213.4	88.6	3068.8	106.2	23.5	1.19	5041	571.3	2.1	13.4	
11/30/98	0:00	511.7															
11/30/98	2:21	496.3	514.1	237.3	228.8	215.0	211.0	86.6	3076.9	101.3	23.0	1.30	5020	561.5	4.1	13.0	
11/30/98	9:38	503.3	521.3	246.2	238.0	224.0	219.9	90.3	3093.3	107.0	26.7	1.33	4988	654.3	1.7	14.2	
11/30/98	18:54	512.2	530.6	245.4	238.0	224.2	219.5	87.4	3076.9	108.2	26.7	1.30	4995	644.5	4.1	15.1	
12/1/98	0:00	535.7															
12/1/98	3:19	521.0	539.0	244.7	237.2	223.5	219.0	87.4	3076.9	106.2	26.2	1.26	5016	644.5	2.9	13.4	
12/1/98	10:37	528.7	546.3	245.3	237.9	224.4	219.8	84.1	3085.1	102.9	26.7	1.24	5009	649.4	1.7	14.7	
12/1/98	17:54	536.3	553.6	245.2	238.4	224.4	220.3	83.7	3060.6	102.5	26.6	1.26	5027	654.3	6.2	14.3	
12/2/98	0:00	559.7															
12/2/98	0:57	544.0	560.7	244.7	237.3	223.7	219.2	83.7	3085.1	102.5	26.9	1.35	5023	654.3	6.2	14.3	
12/2/98	9:19	552.8	569.0	244.5	237.4	223.8	219.7	85.3	3085.1	106.2	26.8	1.32	4984	654.3	3.7	15.1	
12/2/98	16:41	560.5	576.4	244.5	237.4	223.7	219.3	86.2	3076.9	104.9	26.9	1.21	5027	649.4	3.7	13.9	
12/3/98	0:00	583.7															
12/3/98	0:02	568.2	583.7	245.2	237.5	224.4	219.9	85.7	3101.5	104.5	27.0	1.40	5034	654.3	0.5	14.7	
12/3/98	8:23	577.0	592.1	245.5	238.4	224.8	220.3	86.2	3068.8	102.9	26.9	1.24	5037	649.4	3.3	14.3	
12/3/98	17:44	586.9	601.5	244.9	237.8	223.8	219.7	85.7	3076.9	103.7	26.8	1.23	5030	644.5	4.1	15.5	
12/4/98	0:00	607.7															
12/4/98	3:12	596.8	610.9	245.7	238.8	224.9	220.3	87.4	3076.9	107.4	26.4	1.29	5023	649.4	2.9	14.7	
12/4/98	8:26	602.3	616.2	245.7	238.4	224.9	220.7	86.2	3076.9	105.8	26.5	1.39	5005	649.4	3.3	15.5	
12/4/98	9:00	616.7	Stopped														
12/7/98	9:08	616.7	Started														
12/7/98	9:59	604.3	617.5	245.3	238.7	225.4	220.3	83.7	3068.8	105.3	27.3	1.26	5034	664.1	4.1	14.3	
12/7/98	18:10	613.1	625.7	244.7	237.0	223.8	219.3	84.1	3085.1	98.8	26.7	1.23	4984	639.7	5.0	15.1	
12/8/98	0:00	631.6															
12/8/98	2:35	621.8	634.1	244.7	237.5	223.9	219.4	83.7	3101.5	105.8	25.7	1.31	4984	629.9	6.2	15.5	

Pump Test 38 - Throttle Valve Closed

Pump: ABEX Model AP12V-17, S/N MTE 1348

Test Fluid: ML097-322 (MIL-PRF-83282)

Date	Time	Test Hrs.	Actual Test Hrs.	Remarks	case drain out	throttle valve	pump outlet T	pump inlet T	pump outlet P	throttle valve	main flow	case drain	motor speed	motor torque	main filter	delta P filter	case filter	psi
					F	F	F	F	psig	psig	gal	gal	rpm	in-lbf	psi	psi	psi	psi
12/8/98	9:52	629.5	641.4		244.3	236.9	223.4	218.8	82.4	3068.8	100.8	24.3	1.32	5051	595.7	2.5	15.1	
12/8/98	18:05	638.3	649.6		244.4	237.0	223.7	219.4	86.2	3068.8	100.0	24.7	1.32	4984	605.5	2.5	14.3	
12/9/98	0:00		655.6															
12/9/98	1:26	646.0	657.0		244.0	237.3	223.2	219.2	86.2	3085.1	101.3	24.4	1.28	4998	595.7	4.5	14.3	
12/9/98	9:48	654.8	665.4		242.4	235.7	221.5	217.5	83.7	3068.8	102.5	23.6	1.31	5037	585.9	5.4	14.3	
12/9/98	18:03	663.6	673.6		241.5	237.5	223.9	219.9	84.5	3093.3	100.8	23.6	1.30	5034	585.9	3.3	15.1	
12/10/98	0:00		679.6															
12/10/98	1:25	671.3	681.0		244.2	237.8	223.8	219.5	84.9	3109.7	102.1	23.5	1.44	5016	581.1	3.3	15.5	
12/10/98	7:44	677.9	687.3		243.8	237.8	223.8	219.7	84.9	3068.8	100.4	23.5	1.33	4988	576.2	4.1	15.5	
12/10/98	8:38		688.2	Stopped														
1/5/99	13:51		688.2	Started														
1/5/99	14:51	682.8	689.2		245.2	238.0	224.4	219.9	92.8	3036.0	124.1	27.4	1.40	5030	693.3	15.6	11.8	
1/5/99	22:05	690.5	696.4		244.9	237.7	224.2	219.9	91.1	3068.8	115.6	27.4	1.40	5058	693.3	12.7	9.7	
1/6/99	0:00		698.2															
1/6/99	3:30		701.7	Stopped														
1/6/99	10:09		701.7	Started														
1/7/99	0:00		715.6															
1/7/99	6:52	718.1	722.5		243.9	237.5	223.5	219.0	90.7	3060.6	125.0	29.3	1.29	5041	732.4	9.0	10.1	
1/7/99	8:57	720.3	724.6		238.7	231.8	217.9	213.7	87.0	3068.8	120.1	28.3	1.18	4995	708.0	11.9	9.7	
1/7/99	9:11		724.8	Stopped														
1/15/99	12:22		724.8	Started														
1/15/99	13:00	722.3	725.4		243.7	236.4	222.8	217.9	92.4	3068.8	125.8	27.8	1.24	4998	703.1	18.4	10.9	
1/15/99	20:11	730.0	732.6		244.3	237.2	223.2	219.0	88.2	3060.6	115.6	27.9	1.32	5005	698.2	8.6	11.0	
1/16/99	6:41	741.0	743.1		245.7	238.4	224.4	220.4	90.3	3076.9	118.4	27.8	1.35	5009	693.3	13.5	10.9	
1/16/99	7:07		743.6	Stopped														
1/18/99	8:56		743.6	Started														
1/18/99	15:01	748.0	749.7		246.3	238.4	224.7	221.0	91.1	3101.5	120.5	27.9	1.32	4991	703.1	18.8	11.4	
1/18/99	23:24	756.8	758.1		244.8	237.3	222.4	219.2	89.9	3076.9	121.7	27.7	1.32	4981	698.2	14.8	10.9	
1/19/99	0:00		758.7															
1/19/99	7:48	765.6	766.5		245.7	237.8	224.5	220.4	89.5	3076.9	120.1	27.9	1.26	5009	698.2	16.0	11.8	



## Pump Test 38 - Throttle Valve Closed

## Pump: ABEX Model AP12V-17, S/N MTE 1348

## Test Fluid: MLO97-322 (MIL-PRF-83282)

Date	Time	Test Hrs.	Actual Test Hrs.	Remarks	Case drain out T	Throttle valve outlet T	Pump outlet T	Pump inlet T	Pump outlet P psig	Pump inlet P psig	Throttle valve outlet P psig	Main flow gal	Case drain gal	Motor speed rpm	Motor torque in-lbf	Main filter psi	Delta P filter psi	Case filter psi	Delta P filter psi
1/27/99	0:00		939.4																
1/27/99	4:57	953.0	944.4	244.7	238.2	224.3	219.7	88.6	3093.3	115.1	26.9	1.41	4984	678.7	14.3	14.7			
1/27/99	14:20	962.9	953.7	243.9	237.5	223.5	219.5	87.4	3101.5	116.8	27.1	1.35	5016	678.7	16.0	15.1			
1/27/99	14:36		954.0	Stopped															
2/16/99	10:28		954.0	Started															
2/16/99	10:32		954.1	Stopped															
2/17/99	9:43		954.1	Started															
2/17/99	10:14		954.7	Stopped															
2/17/99	11:57		954.7	Started															
2/17/99	12:43		955.8	Stopped															
2/17/99	13:14		955.8	Started															
2/17/99	20:48	973.2	963.4	245.4	238.5	224.7	220.4	87.8	3076.9	119.2	27.1	1.42	5020	678.7	15.6	14.7			
2/18/99	0:00		964.6																
2/18/99	5:12	982.0	969.8	245.4	238.7	224.7	220.5	87.8	3076.9	117.6	26.7	1.32	5020	678.7	13.9	15.9			
2/18/99	13:23	990.7	978.0	245.5	238.4	224.8	220.3	90.3	3076.9	121.3	27.8	1.36	5030	698.2	13.1	13.8			
2/18/99	21:41	999.5	986.3	244.9	238.2	224.2	220.0	89.9	3076.9	121.7	27.5	1.32	5009	693.3	14.8	15.5			
2/19/99	0:00		988.6																
2/19/99	6:05	1008.3	994.7	245.8	238.7	225.0	220.5	90.7	3068.8	120.1	27.3	1.35	4988	683.6	14.8	14.7			
2/19/99	13:13	1016.0	1001.8	245.4	238.7	225.0	220.5	90.7	3060.6	122.9	27.4	1.29	4995	693.3	16.0	14.7			
2/19/99	21:31	1024.6	1010.1	244.9	238.3	224.2	219.7	90.3	3068.8	113.9	27.2	1.42	5041	688.4	15.2	15.5			
2/20/99	0:00		1012.6																
2/20/99	5:55	1031.7	1018.5	245.5	238.8	224.8	220.7	90.3	3060.6	118.8	27.6	1.36	4984	688.4	17.2	15.1			
2/20/99	15:22	1039.6	1028.0	245.8	238.7	224.5	220.9	92.0	3068.8	116.4	27.5	1.30	5041	683.6	16.8	13.8			
2/20/99	23:46	1046.6	1036.4	244.9	237.5	224.2	220.0	91.1	3085.1	118.8	27.6	1.29	4984	683.6	17.6	14.7			
2/21/99	0:00		1036.6																
2/21/99	9:13	1054.5	1045.8	244.5	237.3	223.8	219.2	90.7	3068.8	122.5	27.3	1.37	4998	688.4	15.2	14.2			
2/21/99	18:40	1062.4	1055.3	245.7	237.7	225.4	220.8	91.5	3101.5	122.1	27.0	1.39	4995	678.7	13.5	14.7			
2/22/99	0:00		1060.6																
2/22/99	4:07	1070.3	1064.7	244.8	238.0	224.4	219.9	91.5	3085.1	121.3	27.2	1.41	5020	683.6	12.3	14.2			
2/22/99	13:30	1078.3	1074.1	245.4	238.8	225.2	220.7	91.5	3101.5	118.0	26.8	1.47	5034	678.7	15.6	15.1			

Pump Test 38 - Throttle Valve Closed													
Test Fluid: MLO97-322 (MIL-PRF-83282)													
Date	Time	Actual Test Hrs.	Test Hrs.	Remarks	Throttle Valve			Pump outlet T			Pump inlet T		
					F	F	F	psig	psig	psig	psig	psig	psig
2/22/99	22:54	1086.2	1083.5		244.8	238.0	224.0	220.0	90.3	3109.7	119.2	27.1	1.40
2/23/99	0:00	1084.6											
2/23/99	8:21	1094.1	1093.0		245.3	237.7	224.9	220.8	91.1	3068.8	125.0	26.6	1.41
2/23/99	17:39	1102.0	1102.3		244.3	238.0	224.4	218.7	90.7	3085.1	120.5	26.7	1.46
2/24/99	0:00		1108.6										
2/24/99	3:07	1109.9	1111.7		244.0	237.3	223.2	219.5	89.9	3076.9	118.8	26.7	1.38
2/24/99	12:30	1117.8	1121.1		244.5	237.8	224.2	220.2	89.5	3101.5	114.7	26.5	1.39
2/24/99	22:50	1126.6	1131.4		244.2	236.2	223.8	219.3	90.3	3068.8	119.6	26.9	1.37
2/25/99	0:00		1132.6										
2/25/99	8:17	1134.5	1140.9		244.7	236.8	224.3	220.0	90.3	3126.0	116.4	26.4	1.40
2/25/99	17:35	1142.4	1150.2		244.9	238.7	224.5	220.9	91.1	3085.1	118.8	26.8	1.40
2/26/99	0:00		1156.6										
2/26/99	3:02	1150.3	1159.6		244.2	237.9	224.2	220.2	89.9	3085.1	119.2	26.5	1.38
2/26/99	12:26	1158.2	1169.0		244.7	237.7	224.2	220.4	90.3	3093.3	118.0	26.6	1.37
2/26/99	21:47	1166.1	1178.4		243.8	237.9	223.8	219.8	90.7	3068.8	116.0	26.4	1.39
2/27/99	0:00		1180.6										
2/27/99	7:14	1174.1	1187.8		244.3	238.0	224.4	220.3	89.9	3085.1	119.6	26.5	1.36
2/27/99	16:41	1182.0	1197.3		244.3	237.5	223.9	219.9	89.1	3093.3	117.6	26.4	1.32
2/28/99	0:00		1204.6										
2/28/99	3:11	1190.8	1207.8		244.9	238.7	225.0	220.9	91.1	3093.3	120.1	26.6	1.35
2/28/99	12:37	1198.7	1217.2		243.9	237.7	223.5	219.5	90.3	3093.3	115.6	26.6	1.47
3/1/99	0:00		1228.6										
3/1/99	0:10	1208.3	1228.8		245.2	238.4	224.8	220.7	90.7	3117.8	118.0	26.2	1.45
3/1/99	7:31	1214.5	1236.1		244.3	237.7	224.0	219.9	89.5	3109.7	113.1	26.3	1.48
3/1/99	7:58		1236.6	Stopped									
3/3/99	8:38		1236.6	Started									
3/3/99	8:59	1215.3	1237.0		240.3	233.8	220.2	214.4	91.1	3093.3	119.6	27.3	1.32
3/3/99	18:10	1223.2	1246.1		243.7	237.8	224.0	219.5	85.7	3076.9	117.2	27.7	1.47
3/4/99	0:00		1252.0										
3/4/99	3:38	1231.1	1255.6		244.2	237.8	223.8	219.7	86.6	3068.8	114.7	27.5	1.36

Pump: ABEX Model AP12V-17, S/N MTE 1348

## Pump Test 38 - Throttle Valve Closed

Test Fluid: MLO97-322 (MIL-PRF-83282)

## APPENDIX F

Raw Data for Pump Test 38  
with Purified MIL-PRF-83282

Throttle Valve OPEN

Pump Test 38 - Throttle Valve Open

Pump: ABEX Model AP12V-17, S/N MTE 1348

Test Fluid: MLO97-322 (MIL-PRF-83282)

Date	Time	Test Hrs.	Actual Test Hrs.	Remarks	Case drain out	Throttle valve	Pump outlet T	Pump inlet T	Pump outlet P	Pump inlet P	Throttle valve	Main flow	Case drain	Motor speed	Motor torque	Main filter	Delta P main filter	Case filter	Delta P case filter		
8/11/98	13:15	0.0	Started																		
8/11/98	21:21	8.0	8.2		249.1	242.3	227.8	224.2	97.8	3052.4	130.3	36.2	1.24	5034	874.0	7.4	13.0				
8/12/98	0:00	10.8																			
8/12/98	5:45	16.0	16.6		249.6	242.3	227.6	223.3	94.9	3076.9	127.0	36.1	1.19	4988	878.9	7.0	13.4				
8/12/98	14:04	24.0	24.9		249.1	241.7	227.1	223.4	93.2	3093.3	127.0	36.3	1.31	5058	869.1	9.0	12.6				
8/12/98	22:23	32.0	33.2		249.2	239.4	226.8	223.8	94.0	3085.1	128.2	35.9	1.21	5037	874.0	7.8	13.0				
8/13/98	0:00	34.8																			
8/13/98	6:48	40.0	41.6		249.6	242.7	227.9	222.9	92.4	3076.9	122.5	36.1	1.19	4984	869.1	8.6	12.2				
8/13/98	15:08	48.1	50.0		249.3	242.2	227.8	224.1	93.6	3093.3	125.0	35.8	1.30	4995	864.3	7.4	11.8				
8/13/98	23:30	56.1	58.3		250.2	242.6	227.3	224.1	89.9	3076.9	121.7	36.0	1.29	5037	869.1	9.0	12.2				
8/14/98	0:00	58.8																			
8/14/98	7:55	64.1	66.8		249.6	240.7	227.6	223.8	88.6	3085.1	121.3	35.7	1.16	4988	869.1	5.0	11.8				
8/14/98	14:11	70.0	73.0		249.7	242.1	225.6	223.6	89.1	3093.3	121.3	35.6	1.16	4991	869.1	8.6	12.2				
8/14/98	15:00	73.8	Stopped																		
8/17/98	9:44	73.8	Started																		
8/17/98	12:37	73.6	76.7		249.8	242.7	228.1	223.8	92.8	3093.3	125.0	35.9	1.11	5002	883.8	7.4	12.2				
8/17/98	19:57	80.6	84.0		249.9	241.9	227.4	223.1	93.2	3093.3	125.8	36.2	1.29	4991	874.0	7.0	11.8				
8/18/98	4:20	88.5	92.4		250.2	242.7	227.8	223.7	93.2	3076.9	125.4	36.0	1.18	5051	874.0	5.8	11.3				
8/18/98	12:41	96.4	100.8		251.1	242.7	227.8	224.2	92.8	3076.9	125.0	36.1	1.19	5020	874.0	7.8	13.4				
8/18/98	21:02	104.3	109.1		249.6	242.3	225.4	223.8	93.6	3085.1	125.0	36.1	1.18	5034	874.0	8.6	12.6				
8/19/98	0:00	112.1																			
8/19/98	5:26	112.2	117.5		249.4	241.9	227.1	223.4	91.5	3076.9	123.7	35.7	1.20	5051	874.0	8.6	13.4				
8/19/98	14:45	121.1	126.8		249.8	242.2	227.8	223.7	93.6	3101.5	124.5	36.1	1.12	5012	874.0	9.0	12.2				
8/19/98	23:08	129.0	135.2		250.1	242.3	227.7	222.7	92.8	3085.1	122.9	36.0	1.24	5012	874.0	7.4	12.2				
8/20/98	0:00	136.1																			
8/20/98	7:31	136.9	143.6		250.3	242.6	227.7	223.7	93.2	3101.5	123.7	36.0	1.18	5066	874.0	7.4	12.6				
8/20/98	16:51	145.8	152.9		250.8	242.7	228.3	223.8	93.2	3085.1	127.8	36.1	1.24	5062	874.0	8.6	12.6				
8/21/98	1:13	153.7	161.3		250.3	242.3	227.4	223.8	93.2	3085.1	124.1	35.8	1.21	5051	874.0	7.0	12.2				
8/21/98	9:35	161.6	169.7		249.8	241.8	227.4	223.3	92.4	3101.5	123.3	36.0	1.15	5037	874.0	4.1	10.9				
8/21/98	17:56	169.6	178.0		250.7	242.3	227.8	223.8	94.0	3093.3	126.2	35.9	1.24	5023	869.1	6.6	12.2				

## Pump Test 38 - Throttle Valve Open

Pump: ABEX Model AP12V-17, S/N MTE 1348

Test Fluid: ML097-322 (ML-PRF-83282)

## Pump Test 38 - Throttle Valve Open

## Pump: ABEX Model AP12V-17, S/N MTE 1348

## Test Fluid: MLO97-322 (MIL-PRF-83282)

Date	Time	Test Hrs.	Actual Test Hrs.	Remarks	case drain out	throttle valve	outlet T	pump outlet T	pump inlet T	pump inlet P	throttle valve P	case drain	motor speed	motor torque	main filter psi	delta P psi	case filter psi	delta filter psi	
11/14/98	19:53	306.5	315.3		F	F	247.9	241.2	227.9	91.5	3060.6	120.1	36.1	1.44	4991	878.9	6.2	13.4	
11/14/98	20:32		316.0	Stopped															
11/17/98	12:03		316.0	Started															
11/17/98	14:19	309.9	318.3				247.7	240.4	226.8	89.1	3076.9	114.3	35.8	1.39	4988	874.0	2.9	14.7	
11/17/98	22:36	317.8	326.5				247.2	239.9	226.3	89.1	3052.4	113.5	35.1	1.26	5027	854.5	2.1	13.4	
11/18/98	0:00		327.9																
11/18/98	7:00	325.7	334.9				248.3	240.3	226.7	221.9	89.1	3076.9	117.6	34.2	1.33	5027	835.0	7.8	14.7
11/18/98	15:06	333.6	342.9				247.2	239.0	225.8	221.4	89.5	3085.1	118.0	35.1	1.36	5051	859.4	7.0	14.3
11/18/98	23:25	341.5	351.3				248.9	240.2	226.5	221.7	90.3	3093.3	120.5	34.7	1.35	4995	844.7	5.8	14.7
11/19/98	0:00		351.9																
11/19/98	7:48	349.5	359.7				247.8	239.8	226.2	221.3	89.9	3085.1	119.6	34.2	1.36	5012	835.0	7.4	13.8
11/19/98	15:56	357.4	367.0				248.3	240.7	226.7	221.8	89.9	3093.3	120.1	34.0	1.20	5062	835.0	5.8	15.1
11/20/98	0:16	365.3	376.3				248.4	240.4	226.8	222.4	90.7	3085.1	122.1	34.4	1.31	5069	835.0	4.5	14.7
11/20/98	8:39	373.2	384.5				248.2	240.2	226.5	222.2	90.7	3093.3	118.8	34.5	1.29	4998	835.0	5.0	14.7
11/20/98	16:52	381.1	392.8				248.2	239.7	226.0	221.7	89.1	3076.9	115.6	34.0	1.27	5027	835.0	1.7	15.1
11/21/98	0:00		399.9																
11/21/98	0:13	388.0	400.1				248.4	239.9	225.9	221.3	89.9	3068.8	121.3	34.1	1.27	4984	835.0	9.4	14.3
11/21/98	0:48		400.7	Stopped															
11/25/98	9:17		400.7	Started															
11/25/98	11:17	391.5	402.7				246.4	239.2	225.2	220.7	91.1	3060.6	122.5	36.0	1.29	4991	874.0	7.8	14.7
11/25/98	19:28	399.4	411.2				245.8	239.0	224.5	220.9	92.0	3085.1	124.5	35.1	1.31	4984	859.4	7.0	14.2
11/26/98	0:00		415.7																
11/26/98	4:55	408.3	420.6				246.7	239.0	225.4	221.0	89.9	3076.9	123.3	34.3	1.36	5016	835.0	8.2	13.8
11/26/98	13:19	416.2	429.0				246.0	239.3	225.7	220.8	89.1	3068.8	115.6	33.8	1.33	4998	820.3	7.0	13.4
11/26/98	21:43	424.1	437.4				246.2	239.4	225.0	220.9	88.6	3085.1	117.2	32.6	1.32	5016	791.0	7.0	14.3
11/27/98	0:00		439.7																
11/27/98	6:07	432.1	445.8				237.2	223.5	218.7	85.3	3068.8	110.2	31.7	1.21	4995	766.6	3.7	13.4	
11/27/98	14:31	440.0	454.2				236.4	222.3	217.8	84.9	3085.1	112.3	31.8	1.29	4981	771.5	7.8	13.4	
11/27/98	22:56	447.9	462.6				242.9	235.8	221.7	216.9	85.3	3060.6	109.0	31.4	1.26	5023	761.7	8.6	12.6
11/28/98	8:23	456.8	472.1				241.3	234.0	220.4	215.5	85.3	3085.1	111.9	30.8	1.14	4998	752.0	7.4	13.0

Phmp: ABEX Model AP12Y-17 S/N MTE 1348

## Pump Test 38 - Throttle Valve Open

Test Fluid: ML097-3322 (MIL-PRF-83282)

Date	Time	Actual Hrs.	Test Hrs.	Remarks	Case outlet T	Throttle valve	Pump outlet T	Pump inlet P	Pump outlet P	Throttle valve	Main flow	Case drain	Motor speed	Main filter psi	Deltap filter psi	Case filter psi	Deltap filter psi	Case filter psi
11/28/98	16:47	464.7	480.5		240.8	233.2	218.8	214.7	84.5	3068.8	107.8	30.8	1.14	5009	742.2	6.6	12.6	
11/29/98	0:00		487.7															
11/29/98	1:07	472.6	488.8		242.7	235.0	221.4	216.7	90.7	3076.9	118.8	30.7	1.19	5062	747.1	6.6	13.0	
11/29/98	9:31	480.5	497.2		242.4	235.2	220.4	216.7	90.7	3093.3	113.9	30.5	1.18	5005	742.2	5.8	13.0	
11/29/98	17:56	488.4	505.6		242.4	235.2	221.5	216.7	90.7	3076.9	115.6	30.1	1.20	5023	737.3	0.5	12.6	
11/30/98	0:00		511.7															
11/30/98	2:20	496.3	514.0		240.5	233.2	219.2	214.7	89.9	3093.3	111.9	29.8	1.15	4984	727.5	5.8	12.6	
11/30/98	9:37	503.2	521.3		246.2	239.4	225.8	220.0	94.0	3085.1	113.9	35.3	1.30	4991	869.1	1.3	15.9	
11/30/98	18:53	512.2	530.6		247.4	239.3	225.8	220.4	91.5	3076.9	108.6	35.1	1.27	5037	854.5	-4.9	16.7	
12/1/98	0:00		535.7															
12/1/98	3:18	520.9	539.0		246.7	239.2	225.5	220.7	91.1	3085.1	110.7	34.6	1.40	5034	844.7	0.5	15.5	
12/1/98	10:36	528.6	546.3		247.3	239.7	225.7	220.0	88.2	3093.3	125.4	35.5	1.46	5012	869.1	8.6	15.1	
12/1/98	17:53	536.3	553.6		247.2	239.5	225.9	221.2	87.4	3085.1	116.0	35.4	1.45	5037	859.4	6.6	15.5	
12/2/98	0:00		559.7															
12/2/98	0:56	544.0	560.6		246.7	238.9	225.4	220.4	87.0	3068.8	113.5	35.4	1.28	5041	854.5	10.3	15.5	
12/2/98	9:18	552.8	569.0		246.5	239.0	225.4	220.5	89.9	3068.8	119.6	34.9	1.37	4984	849.6	8.2	15.1	
12/2/98	16:39	560.5	576.4		246.2	238.9	224.9	220.9	88.6	3076.9	116.8	34.8	1.29	5002	849.6	7.4	15.5	
12/3/98	0:00		583.7															
12/3/98	0:01	568.2	583.7		246.8	239.5	225.9	221.2	87.8	3068.8	115.1	34.4	1.32	5034	844.7	5.4	17.1	
12/3/98	8:22	577.0	592.1		246.8	239.4	225.8	221.2	89.5	3068.8	114.7	34.5	1.36	5030	835.0	6.6	15.1	
12/3/98	17:43	586.9	601.4		246.5	239.4	225.8	220.9	90.7	3085.1	117.2	34.1	1.42	4995	835.0	5.8	14.2	
12/4/98	0:00		607.7															
12/4/98	3:11	596.8	610.9		247.3	239.9	226.5	221.9	88.6	3093.3	118.8	34.1	1.30	5020	830.1	2.5	18.0	
12/4/98	8:25	602.2	616.1		246.9	240.2	226.3	221.7	89.1	3085.1	110.7	34.1	1.38	5041	825.2	1.7	15.9	
12/4/98	9:00		616.7	Stopped														
12/7/98	9:08		616.7	Started														
12/7/98	9:58	604.3	617.5		245.9	240.0	226.4	221.5	90.3	3068.8	120.1	34.3	1.35	4981	830.1	12.7	15.9	
12/7/98	18:09	613.0	625.9		245.8	239.0	225.4	220.9	88.6	3068.8	116.0	34.4	1.30	5044	830.1	6.6	15.5	
12/8/98	0:00		631.6															
12/8/98	2:34	621.8	634.1		246.3	238.7	225.9	221.3	88.2	3085.1	117.2	33.7	1.35	4991	820.3	6.6	16.3	

## Pump Test 38 - Throttle Valve Open

Pump: ABEX Model AP12V-17, S/N MTE 1348

Test Fluid: MLO97-322 (MIL-PRF-83282)

## Pump: ABEX Model AP12V-17, S/N MTE 1348

## Pump Test 38 - Throttle Valve Open

## Test Fluid: MLO97-322 (MIL-PRF-8332B)

Date	Time	Actual Test Hrs	Test Hrs	Remarks	Throttle valve	Pump outlet T	Pump inlet T	Pump outlet P	Pump inlet P	Main flow gal	Case drain gal	Motor speed rpm	Motor torque in-lbf	Main filter psi	Case filter psi	Main filter P	Case filter P	
					Case drain out	Throttle valve	Case drain out	Throttle valve	Case drain	Motor speed	Motor torque	Case filter	Motor torque	Case filter	Main filter	Case filter	Main filter P	Case filter P
1/18/99	8:56		743.6	Started	F	F	F	F	F	3085.1	132.7	34.6	1.32	4988	864.2	19.3	10.9	
1/18/99	14:59	748.0	749.7		247.2	239.5	225.5	221.4	94.4	3085.1	133.1	34.2	1.31	4988	849.6	18.4	11.8	
1/19/99	23:23	756.8	758.1		245.7	237.8	224.5	220.0	91.5	3068.8								
1/19/99	0:00		758.7															
1/19/99	7:47	765.6	766.5		246.4	239.2	225.3	220.4	92.4	3093.3	134.3	33.8	1.26	5023	849.6	17.6	11.8	
1/19/99	15:59	774.4	774.7		245.3	234.7	223.0	219.4	89.1	3060.6	128.6	34.5	1.26	4977	854.5	20.9	11.8	
1/20/99	0:00		782.7															
1/20/99	0:20	783.2	783.0		246.0	238.9	225.3	220.4	90.7	3076.9	128.2	34.2	1.26	4991	849.6	16.8	11.4	
1/20/99	8:43	791.9	791.4		245.5	238.4	224.9	220.3	88.2	3101.5	126.2	34.4	1.35	4984	854.5	18.4	13.4	
1/20/99	16:58	800.7	799.7		246.5	239.4	225.8	221.3	90.3	3068.8	130.7	34.3	1.39	5044	849.6	17.6	12.2	
1/21/99	0:00		806.7															
1/21/99	1:22	809.5	808.1		245.8	237.8	225.0	220.0	89.1	3093.3	128.6	33.9	1.22	4998	849.6	18.0	12.6	
1/21/99	9:41	818.3	816.4		246.4	239.3	225.7	220.4	91.1	3085.1	131.1	34.3	1.36	4977	849.6	16.8	11.4	
1/21/99	18:04	827.1	824.8		246.7	239.2	225.5	221.0	88.2	3093.3	126.6	34.2	1.29	4998	844.7	18.0	14.3	
1/22/99	0:00		830.7															
1/22/99	3:31	837.0	834.2		245.2	237.9	224.3	219.9	89.5	3076.9	129.4	34.0	1.27	5058	844.7	14.8	12.6	
1/22/99	13:49	848.0	844.5		246.4	239.5	225.9	221.0	89.1	3076.9	125.8	33.9	1.40	4995	834.9	16.8	13.4	
1/22/99	23:08	857.9	853.8		246.0	238.9	224.4	220.8	89.5	3101.5	128.6	33.8	1.33	5041	834.9	19.3	12.6	
1/23/99	0:00		854.7															
1/23/99	8:34	867.7	863.3		244.8	238.4	224.7	220.3	88.2	3109.7	127.4	33.3	1.39	5030	834.9	16.8	14.3	
1/23/99	18:01	877.6	872.7		246.0	238.9	225.3	218.8	87.0	3093.3	122.1	33.5	1.39	4988	830.0	17.2	15.5	
1/24/99	0:00		878.7															
1/24/99	3:27	887.5	882.2		246.2	239.3	224.2	220.8	89.5	3101.5	127.0	33.4	1.30	5020	830.0	16.8	13.8	
1/24/99	11:51	896.3	890.5		245.0	238.3	224.7	220.2	88.2	3068.8	127.4	33.2	1.35	4998	839.8	16.0	14.3	
1/24/99	20:14	905.1	898.9		245.8	237.0	225.4	220.5	87.4	3076.9	127.8	33.2	1.24	5034	830.0	16.8	15.1	
1/24/99	23:23	908.4	902.1		245.0	238.7	225.0	220.5	89.5	3085.1	126.2	33.2	1.33	4977	830.0	16.8	14.3	
1/25/99	0:00		902.7															
1/25/99	0:03		902.8	Stopped														
1/25/99	11:24		902.8	Started														
1/25/99	12:17	910.1	903.7		247.7	239.0	226.0	221.0	90.3	3076.9	131.5	34.9	1.30	5012	874.0	15.6	12.2	

## Pump Test 38 - Throttle Valve Open

PPump: ABEX Model AP12V-17, S/N MTE 1348

Test Fluid: MLO97-322 (MIL-PRF-83328)

Pump: ABEX Model AP12V-17, S/N MTE 1348

## Pump Test 38 - Throttle Valve Open

Test Fluid: ML097-322 (MIL-PRF-83282)

## Pump Test 38 - Throttle Valve Open

Pump: ABEX Model AP12V-17. S/N MTE 1348

Test Fluid: ML097-322 (ML-PBF-83282)

Pump Test 38 - Throttle Valve Open											
Test Fluid: MIL-O97-322 (MIL-PRF-83282)											
Date	Time	Actual Hrs.	Test Hrs.	Remarks		Case drain out	Throttle valve	Pump outlet T	Pump inlet T	Pump outlet P	Throttle valve
				F	F						
3/3/99	8:38		1236.6	Started							
3/3/99	8:58	1215.2	1236.9	241.3	234.9	218.4	215.0	95.3	3109.7	133.1	1.29
3/3/99	18:09	1223.1	1246.1	245.3	238.5	224.9	220.4	89.1	3068.8	133.9	1.32
3/4/99	0:00		1252.0								
3/4/99	3:37	1231.1	1255.6	245.3	238.5	225.3	220.5	90.3	3068.8	129.4	34.8
3/4/99	12:55	1239.0	1264.9	245.8	239.4	226.2	221.4	91.5	3076.9	131.5	34.5
3/4/99	23:21	1247.8	1275.3	245.7	239.7	226.0	221.2	89.1	3068.8	129.4	34.3
3/5/99	0:00		1276.0								
3/5/99	9:42	1256.5	1285.7	245.3	239.8	226.2	221.3	91.5	3068.8	126.6	34.6
3/5/99	19:58	1264.5	1296.0	244.9	238.5	225.3	220.4	88.2	3068.8	132.3	34.6
3/5/99	0:00		1300.0								
3/6/99	5:25	1272.4	1305.4	245.0	238.5	225.2	220.4	88.6	3085.1	132.7	34.5
3/6/99	14:53	1280.3	1314.9	245.7	239.2	225.8	221.2	90.7	3101.5	126.2	34.5
3/7/99	0:00		1324.0								
3/7/99	0:20	1288.2	1324.3	245.8	239.4	225.8	221.3	89.1	3060.6	129.0	34.3
3/7/99	9:47	1296.1	1333.8	244.4	238.4	224.8	220.2	89.1	3068.8	129.4	34.2
3/7/99	20:18	1304.9	1344.3	245.3	238.9	225.3	220.7	92.0	3076.9	123.3	33.9
3/8/99	0:00		1348.0								
3/8/99	5:45	1312.8	1353.8	244.3	239.2	225.9	221.0	91.1	3101.5	131.9	34.1
3/8/99	16:06	1321.6	1364.1	244.7	238.3	224.7	220.2	87.0	3085.1	123.7	34.1
3/9/99	0:00		1372.0								
3/9/99	1:32	1329.5	1373.5	245.4	239.4	225.4	221.0	91.1	3085.1	127.0	34.2
3/9/99	10:51	1337.4	1382.8	244.4	238.2	224.5	220.0	91.1	3085.1	129.9	34.0
3/9/99	20:14	1345.3	1392.2	244.0	238.8	225.2	220.4	88.6	3093.3	122.5	33.9
3/10/99	0:00		1396.0								
3/10/99	5:41	1353.2	1401.7	246.4	238.7	226.0	221.4	91.5	3085.1	129.9	33.9
3/10/99	15:01	1361.1	1411.0	246.3	239.0	225.4	220.2	89.9	3101.5	129.9	34.1
3/11/99	0:00		1420.0								
3/11/99	0:25	1369.0	1420.4	245.0	238.3	224.3	220.2	89.5	3093.3	129.0	33.9
3/11/99	9:47	1377.0	1429.8	247.3	239.2	226.0	221.0	92.0	3076.9	131.1	33.8



Pump Test 38 - Throttle Valve Closed										Test Fluid: MLO97-322 (MIL-PRF-83282)								
Date	Time	Test Hrs.	Actual Test Hrs.	Remarks	Case drain outlet T	Throttle valve outlet T	Pump inlet T	Pump outlet P	Throttle valve outlet P	Main flow	Case drain	Motor speed	Motor torque	Main filter P	Case filter P	Delta P	psi	psi
3/13/99	1:30	1410.4	1469.5		F	F	F	psig	psig	gal	gal	rpm	in-lbf	psi	psi			
3/13/99	1:56		1469.9	Stopped	248.4	238.0	224.8	220.9	83.7	3101.5	114.7	26.4	1.64	5041	683.6	15.2	35.7	
3/15/99	14:31	1469.9	Started															
3/15/99	18:49	1414.4	1474.2		244.7	238.3	224.3	220.5	88.6	3101.5	115.6	26.6	1.57	4981	683.6	13.1	31.2	
3/16/99	0:00		1479.4															
3/16/99	5:19	1423.2	1484.7		247.3	237.8	224.0	220.0	89.1	3117.8	116.8	26.3	1.45	5051	678.7	14.3	35.7	
3/16/99	14:40	1431.1	1494.1		247.9	238.4	224.3	220.7	80.8	3093.3	108.6	26.3	1.59	4984	678.7	16.0	41.9	
3/17/99	0:00		1503.4															
3/17/99	0:04	1439.0	1503.5		248.3	237.9	223.9	220.3	81.6	3117.8	110.2	26.1	1.56	4995	683.6	18.0	47.7	
3/17/99	8:25	1446.0	1511.8		248.5	237.8	222.4	220.4	82.4	3126.0	112.7	25.9	1.58	5002	678.7	14.8	56.8	
3/17/99	9:28	1446.9	1512.9		249.5	238.4	222.3	221.0	81.6	3101.5	113.1	26.1	1.65	5037	683.6	13.9	62.6	
3/17/99	10:03	1447.4	1513.4	Stopped	258.5	239.3	225.3	221.7	85.7	3126.0	124.5	33.0	1.23	5034	869.1	18.0	55.9	